# BLACKSTONE RIVER BASIN

# 1998 WATER QUALITY ASSESSMENT REPORT

Blackstone River - View from King Phillip's Rock, Northbridge

**COMMONWEALTH OF MASSACHUSETTS**
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# BLACKSTONE RIVER BASIN

# 1998 WATER QUALITY ASSESSMENT REPORT

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  - Bureau of Waste Prevention
  - Bureau of Waste Site Cleanup
- Massachusetts Department of Public Health (MA DPH)
- Department of Fisheries, Wildlife, and Environmental Law Enforcement (DFWELE)
  - Division of Fisheries and Wildlife
  - Riverways Program
- Department of Environmental Management (DEM)

Federal

- Environmental Protection Agency (EPA)
- United States Army Corps of Engineers (ACOE)
- United States Geological Survey (USGS)
  - Water Resources Division

Regional

- Worcester DPW
- Blackstone River Watershed Association
- Blackstone Headwaters Coalition
- Tatnuck Brook Stream Team
- Coes and Patches Watershed Association
- Flint Pond Stream Team
- Miscoe Brook Stream Team

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Cover photo credit: Blackstone River - Robert J. Maietta, DEP Division of Watershed Management

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## LIST OF ACRONYMS

| | |
|---|---|
| 7Q10 | Seven-day, ten-year low flow estimate |
| ACEC | Areas of Critical Environmental Concern |
| ACOE | United States Army Corps of Engineers |
| BDL | below detection limit |
| BMP | best management practice |
| BRWA | Blackstone River Watershed Association |
| BPJ | best professional judgement |
| CFS | cubic feet per second |
| CMR | Code of Massachusetts Regulations |
| CNOEC | chronic no observed effect concentration |
| CWA | Clean Water Act |
| DDT | Dichlordiphenyltrichloroethane |
| DEM | Department of Environmental Management |
| DEP | Department of Environmental Protection |
| DFWELE | Department of Fisheries, Wildlife, and Environmental Law Enforcement |
| DMR | Discharge Monitoring Report |
| DNAPL | Dense Non-Aqueous Phase Liquids |
| DO | Dissolved oxygen |
| DPH | Massachusetts Department of Public Health |
| DWM | DEP's Divison of Watershed Management |
| EPA | United States Environmental Protection Agency |
| FERC | Federal Energy Regulatory Commission |
| GIS (MassGIS) | Geographic Information System |
| GPM (D) | gallons per minute (day) |
| $LC_{50}$ | lethal concentration to 50% of the test organisms |
| MGD | million gallons per day |
| mg/L | milligram per liter |
| NCCW | non-contact cooling water |
| $NH_3$-N | ammonia-nitrogen |
| NPDES | National Pollutant Discharge Elimination System |
| NPS | non point source |
| NTU | nephelometric turbidity units |
| ORW | Outstanding Resource Waters |
| PAH | polyaromatic hydrocarbons |
| PALIS | Pond and Lake Information System |
| PCB | polychlorinated biphenols |
| PPM | parts per million |
| PWS | Public Water Supply |
| QAPP | Quality Assurance Project Plan |
| QA/QC | Quality Assurance/ Quality Control |
| RBP | Rapid Bioassessment Protocol |
| SARIS | Stream and River Inventory System |
| SS | suspended solids |
| SU | standard units |
| SWQS | Massachusetts Surface Water Quality Standards |
| TMDL | total maximum daily load |
| TOC | total organic carbon |
| TOXTD | MA DEP DWM Toxicity Testing Database |
| TRC | total residual chlorine |
| UBWPAD | Upper Blackstone Water Pollution Abatement District |
| USGS | United States Geological Survey |
| WBID | Water Body Identification Code |
| WMA | Water Management Act |
| WWTP | Waste Water Treatment Plant |

# EXECUTIVE SUMMARY
# BLACKSTONE RIVER BASIN 1998
# WATER QUALITY ASSESSMENT REPORT

The Massachusetts Surface Water Quality Standards (SWQS) designate the most sensitive uses for which surface waters in the state shall be protected. The assessment of current water quality conditions is a key step in the successful implementation of the Watershed Approach. This critical phase provides an assessment of whether or not the designated uses are being met (support, partial support, non-support) or are not assessed, as well as basic information needed to focus resource protection and remediation activities later in the watershed management planning process. The Blackstone, Middle, Mill, West and Peters rivers, a portion of the Mumford River, "Mill" and Tatnuck brooks, and a portion of Kettle Brook as well as 88 lakes are on the 1998 303(d) list of impaired waters. Total Maximum Daily Load (TMDL) reports have been or are being developed for some of these waters.

This report presents a summary of current water quality data/information as it relates to assessing the status of the State's designated uses for 13 named streams, brooks, creeks or rivers (the term "rivers" will hereafter be used to include all) and for 116 lakes, ponds or impoundments (the term "lakes" will hereafter be used to include all) in the Blackstone River Basin. These data represent approximately 15% (13 of 88) of the named rivers and about 55% (113.8 of 207.4) of the river miles in the basin. Detailed information for 19 individual river segments totaling 113.8 river miles is presented for the following designated uses: *Aquatic Life, Fish Consumption, Drinking Water, Primary* and *Secondary Contact Recreation* and *Aesthetics*. The report also presents a summary of current information for 116 of the 188 lakes (62%) representing approximately 79% (5,625 of the 7,086.6) of the lake acreage in the Blackstone River Basin. The remaining rivers and lakes (small and/or unnamed) are currently unassessed.

This report contains detailed guidance used for assessing the status each designated use. Each use, within a given segment, is individually assessed as 1) ***support***, 2) ***partial support***, or 3) ***non-support***. The term ***threatened*** is used when the use is fully supported but may not support the use within two years because of adverse pollution trends or anticipated sources of pollution. When too little current data/information exists or no reliable data are available the use is ***not assessed.*** It is important to note, however, that not all waters are assessed. Many small and/or unnamed rivers and lakes are currently ***unassessed***; the status of their designated uses has never been reported to EPA in the state's 305(b) report nor is information on these waters maintained in the Water Body System (WBS) database.

## BLACKSTONE RIVER BASIN - RIVERS

Water quality conditions in the Blackstone River Basin can be summarized as follows: headwaters (Dark, Kettle, Tatnuck, Beaver, "Mill" brooks which flow into the Middle River); the mainstem Blackstone River; and major tributaries to the mainstem (Quinsigamond, Mumford, West, Mill, and Peters rivers). The 13 rivers included in this report (totaling 113.8 river miles) are briefly described below:

- *Headwaters:* A total of 26.6 river miles along six rivers (Dark, Kettle, Tatnuck, Beaver, and "Mill" brooks and the Middle River) were assessed in this area. These rivers drain the city of Worcester and its surrounding area, some of which are protected for public water supply.

- *Blackstone River*: The entire mainstem Blackstone River in Massachusetts (28.8 river miles).

- *Major Tributaries*: A total of 58.4 river miles along five rivers (Quinsigamond, Mumford, West, Mill, and Peters rivers) and Poor Farm Brook (a tributary to Lake Quinsigamond).

A summary of the *Aquatic Life, Fish Consumption, Drinking Water, Primary* and *Secondary Contact Recreation,* and *Aesthetics* uses in these rivers is provided below. When sufficient data/current information was not available, the uses were not assessed.

### *AQUATIC LIFE USE - RIVERS*

The *Aquatic Life Use* is supported when suitable habitat (including water quality) is available for sustaining a native, naturally diverse, community of aquatic flora and fauna. Impairment of the *Aquatic Life Use* (non-support or partial support) may result from anthropogenic stressors that include point and/or nonpoint source(s) of pollution and hydrologic modification.

The status of the *Aquatic Life Use* in the Blackstone River Basin is as follows:

| ***Aquatic Life Use Summary – Rivers (miles)*** | | | |
|---|---|---|---|
| **SUPPORT** | **PARTIAL SUPPORT** | **NON-SUPPORT** | **NOT ASSESSED** |
| **28.5** | **12.1** | **39.8** | **33.4** |

As illustrated in Figure 1, one quarter of the river miles assessed in the Blackstone River Basin support the *Aquatic Life Use* while approximately 45% are impaired (partial or non-support). The remaining 29% of the 113.8 river miles included in this report were not assessed. The assessment of the *Aquatic Life Use* is as follows:

- *Headwaters:* All of the 26.6 river miles in this area were assessed for the *Aquatic Life Use.* A portion of only one stream (the upper 3.5 miles of Kettle Brook) was assessed as supporting this use. The majority, 87%, of the river miles along Dark, Kettle, Tatnuck, Beaver, and "Mill" brooks and the Middle River) were impaired (partial or non-support). Causes of impairment, when known, included organic enrichment, flow and habitat alteration (channelization), habitat degradation (sedimentation), and whole effluent toxicity. Sources of impairment, when known, included urban runoff/storm water, habitat modification, hydromodification (impoundments) and an industrial point source discharge.

- *Blackstone River*: The entire 28.8 mile length of the mainstem Blackstone River in Massachusetts was assessed as non-support for the *Aquatic Life Use.* Habitat alteration, organic enrichment, elevated nutrients, instream and whole effluent toxicity, sediment contamination (heavy metals), and flow alteration were identified as causes of impairment. Sources, when known, included municipal point source and combined sewer overflow discharges, urban runoff/storm water, contaminated sediments and hydromodification (hydropower operations).

- *Major Tributaries*: Portions of three tributaries, the Mumford, West, and Mill rivers, totaling 25 river miles were assessed as supporting the *Aquatic Life Use.* The remaining 33.4 river miles of these major tributaries were not assessed for this use.

# BLACKSTONE RIVER BASIN
# AQUATIC LIFE USE ASSESSMENT SUMMARY - RIVERS

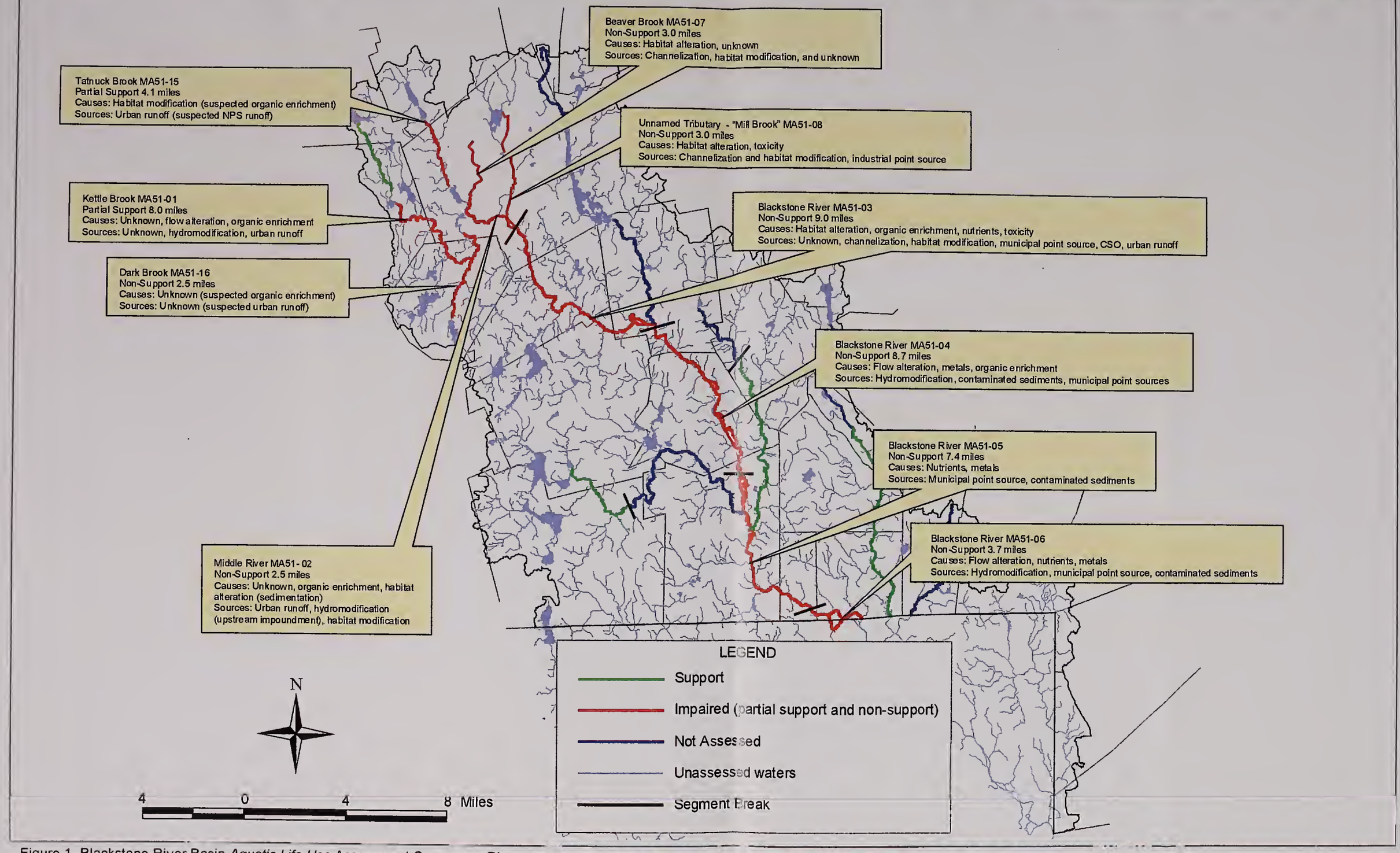


Figure 1. Blackstone River Basin *Aquatic Life Use* Assessment Summary - Rivers

### *FISH CONSUMPTION USE – RIVERS*

The *Fish Consumption Use* is met when there are no pollutants present that result in unacceptable concentrations in edible portions of marketable fish or shellfish or for the recreational use of fish, shellfish, other aquatic life or wildlife for human consumption. The assessment of this use is made using the most recent list of Fish Consumption Advisories issued by the Massachusetts Executive Office of Health and Human Services, Department of Public Health (DPH), Bureau of Environmental Health Assessment (MA DPH 1999). The DPH list identifies waterbodies where elevated levels of a specified contaminant in edible portions of freshwater species poses a health risk for human consumption; hence the *Fish Consumption Use* is assessed as non-support in these waters. In 1994, DPH also issued a statewide "Interim Freshwater Fish Consumption Advisory" for mercury (MA DPH 1994). This precautionary measure was aimed at pregnant women only; the general public was not considered to be at risk from fish consumption. DPH's interim advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially. Because of this statewide interim advisory, no fresh waters can be assessed as support or partial support of the *Fish Consumption Use*.

The status of the *Fish Consumption Use* in the Blackstone River Basin is as follows:

| ***Fish Consumption Use Summary – Rivers (miles)*** | | | |
|---|---|---|---|
| **SUPPORT** | **PARTIAL SUPPORT** | **NON-SUPPORT** | **NOT ASSESSED** |
| 0 | 0 | 6.7 | 107.1 |

DPH issued advisories for three impoundments along the mainstem Blackstone River (Riverdale Pond, Rice City Pond, and the Blackstone River Impoundment above the Blackstone Gorge) as well as a reach of the Mill River (the outlet of Hopedale Pond to the Spindleville Pond Dam) because of elevated PCB concentrations in fishes (MA DPH 1999). The *Fish Consumption Use* is therefore assessed as non-support for a total of five miles of the mainstem Blackstone River and a 1.7-mile reach of the Mill River. No other river miles were assessed for the *Fish Consumption Use* in the Blackstone River Basin.

### *DRINKING WATER USE – RIVERS*

The term *Drinking Water Use* has been used to indicate sources of public drinking water. While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at http://www.state.ma.us/dep/brp/dws/dwshome.htm and from the Blackstone River Basin's public water suppliers. These waters are subject to stringent regulation in accordance with the Massachusetts Drinking Water Regulations. DEP's Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act. DWP has also initiated work on its Source Water Assessment Program (SWAP) which requires that the state delineate protection areas for all public ground and surface water sources; inventory land uses in these areas that may present potential threats to drinking water quality; determine the susceptibility of water supplies to contamination from these sources; and publicize the results. Except for Suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality) public water suppliers monitor their finished water (tap water) for major categories of contaminants (e.g., bacteria, volatile and synthetic organic compounds, inorganic compounds, etc.) and report their data to DWP.

## RECREATIONAL USES - RIVERS

### *PRIMARY AND SECONDARY CONTACT*

The *Primary Contact Recreational Use* is supported when conditions are suitable (fecal coliform bacteria densities meet surface water quality standards) for any recreational or other water activity during which there is prolonged and intimate contact with the water with a significant risk of ingestion. Activities include, but are not limited to, wading, swimming, diving, surfing and water skiing. The *Secondary Contact Recreational Use* is supported when conditions are suitable for any recreational or other water use during which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities.

The status of the *Primary* and *Secondary Contact Recreational* uses in the Blackstone River Basin is as follows:

| ***Primary* and *Secondary Contact Recreational Use Summary – Rivers (miles)*** | | | |
|---|---|---|---|
| **SUPPORT** | **PARTIAL SUPPORT** | **NON-SUPPORT** | **NOT ASSESSED** |
| 8.8 | 11.7 | 26.2 | 67.7 |

As illustrated in Figure 2, only a portion of the West River (from the Upton WWTP to its confluence with the Blackstone River) was assessed as supporting the *Primary* and *Secondary Contact Recreational* uses. While one third (33%) of the assessed river miles in the Blackstone River Basin were impaired (partial or non-support) for these uses, approximately 60% of the river miles were not assessed. The assessment of the recreational uses is as follows:

- *Headwaters:* The *Primary* and *Secondary Contact Recreational* uses were assessed as non-support for the entire lengths of Beaver and "Mill" brooks and the Middle River (8.5 river miles) representing approximately 32% of the river miles in this area. The remaining three brooks, Kettle, Dark and Tatnuck, were not assessed (18.1 river miles). Impairment of the *Primary* and *Secondary Contact Recreational* uses was a result of elevated fecal coliform bacteria and aesthetic degradation (oil, grease and odors) from urban runoff/storm water and illicit sewer connections.

- *Blackstone River*: The entire 28.8 mile length of the mainstem Blackstone River in Massachusetts was assessed as either partial or non-support for the *Primary* and *Secondary Contact Recreational* uses because of elevated fecal coliform bacteria, turbidity, and odor. Sources, when known, included municipal point source and combined sewer overflow discharges, illicit sewer connections, and urban runoff/storm water.

- *Major Tributaries*: A portion of only one tributary, an 8.8 mile reach of the West River, was assessed as support for the *Primary* and *Secondary Contact Recreational* uses. The remaining 49.6 river miles (representing 85% of the 58.4 major tributary river miles) were not assessed for these uses.

# BLACKSTONE RIVER BASIN
## PRIMARY AND SECONDARY CONTACT RECREATIONAL USE ASSESSMENT SUMMARY - RIVERS

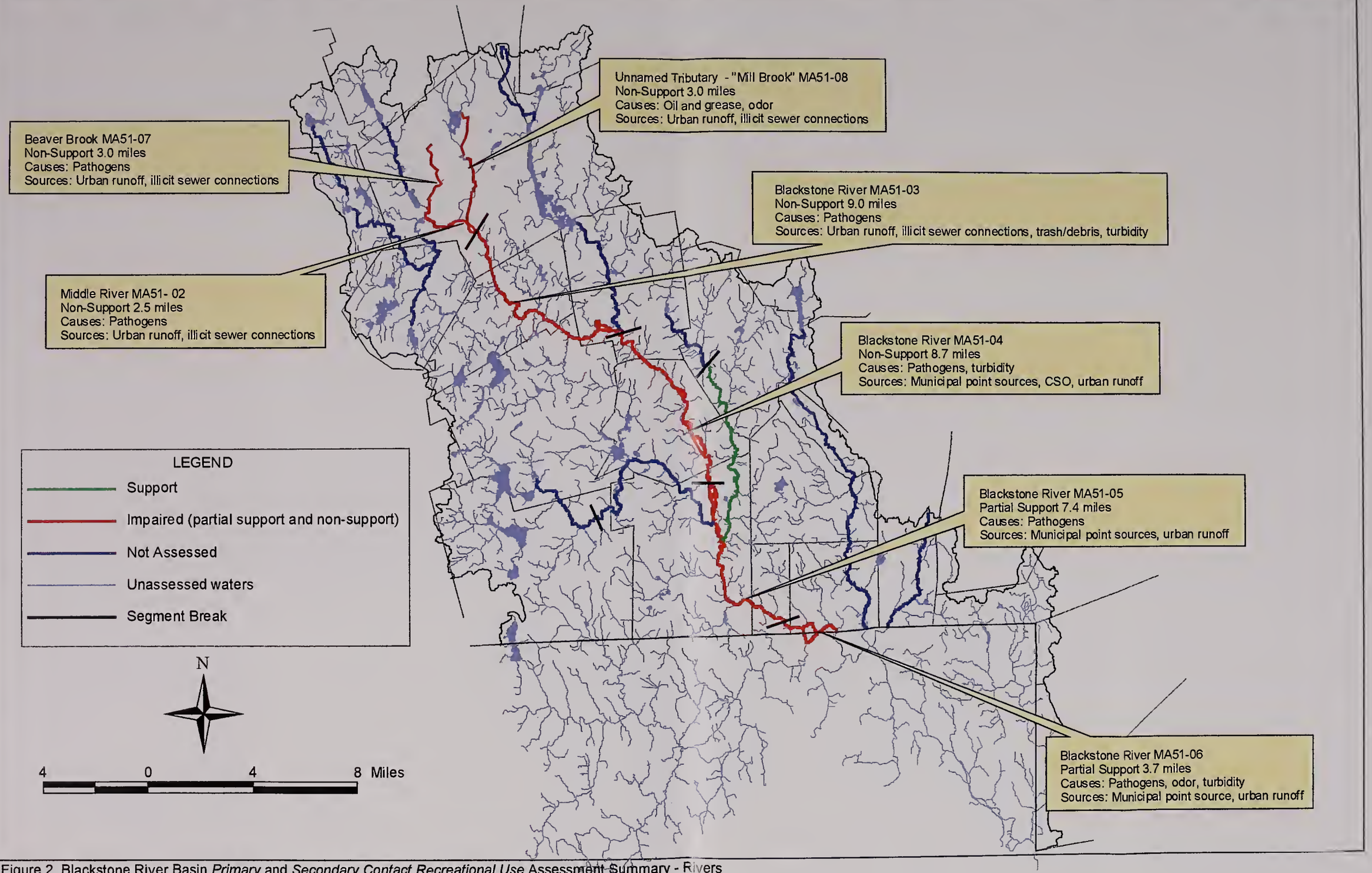


Figure 2. Blackstone River Basin *Primary* and *Secondary Contact Recreational Use* Assessment Summary - Rivers

### *AESTHETICS USE - RIVERS*

The *Aesthetics Use* is supported when surface waters are free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

The status of the *Aesthetics Use* in the Blackstone River Basin is as follows:

| ***Aesthetics Use Summary – Rivers (miles)*** | | | |
|---|---|---|---|
| **SUPPORT** | **PARTIAL SUPPORT** | **NON-SUPPORT** | **NOT ASSESSED** |
| 31 | 23.2 | 26.2 | 33.4 |

Approximately 27% of the river miles (portions of Kettle Brook, the Mumford, West and Mill rivers, and the entire length of Dark Brook) were assessed as supporting the *Aesthetics Use*. Forty-three percent of the assessed river miles in the Blackstone River Basin were impaired (partial or non-support) for this use, while 29% of the 113.8 river miles included in this report were not assessed. The assessment of the *Aesthetics Use* is as follows:

- *Headwaters:* A 3.5 mile reach of Kettle Brook and the entire length of Dark Brook (2.5 river miles) were assessed as support for the *Aesthetics Use*. The entire length of Beaver, Tatnuck and "Mill" brooks and the Middle River (12.6 river miles) and the lower 8.0 miles of Kettle Brook, representing approximately 77% of the river miles in the headwaters area, were impaired (partial or non-support. Impairment of the *Aesthetics Use* was a result of aesthetic degradation (trash/debris, turbidity, oil, grease and odors) from urban runoff/storm water and illicit sewer connections.

- *Blackstone River*: The entire 28.8 mile length of the mainstem Blackstone River in Massachusetts was assessed as either partial or non-support for the *Aesthetics Use* because of objectionable conditions (trash/debris, turbidity and odor). Sources, when known, included municipal point source and combined sewer overflow discharges, illicit sewer connections, and urban runoff/storm water.

- *Major Tributaries*: Portions of three tributaries, the Mumford, West, and Mill rivers, totaling 25 river miles were assessed as supporting the *Aesthetics Use*. The remaining 33.4 river miles (representing 57% of the 58.4 major tributary river miles) were not assessed for this use.

### SUMMARY - RIVERS

In addition to specific issues for the individual river segments, the evaluation of current water quality conditions in the Blackstone River Basin has revealed the need for the following:

- Implement and track the progress of combined sewer overflow (CSO) abatement activities, identify other sources of bacteria and storm water contaminants (e.g., illicit sewer connections) and remediate problems,
- Reduce the impacts of storm water runoff in the Blackstone River Basin by
  - evaluating storm water management practices and pollution prevention plans,
  - enforcing compliance with storm water regulations (construction sites, highway operation and maintenance activities, Phase I and Phase II Communities of the National Pollutant Discharge Elimination System – NPDES Storm Water Program),
  - implementing Best Management Practices - BMPs (e.g., restoration of riparian vegetative buffers, erosion controls, etc.) with ensured operation and maintenance plans, and
  - educating the public
- Conduct bacteriological monitoring (use indicator organism specified in the Massachusetts Surface Water Quality Standards - SWQS) to assess the effectiveness of the CSO and storm water remediation projects as well as to assess the status of the *Primary* and *Secondary Contact Recreational* uses,

- Conduct stream cleanups and encourage/strengthen local stewardship,
- When the DEP Drinking Water Program SWAP evaluations are completed, review them, and develop and implement recommendations to protect the Class A rivers in the Blackstone River Basin.
- Continue to evaluate compliance with Water Management Act (WMA) registration and permit limits,
- Optimize water withdrawal and reservoir management practices to maintain minimum streamflow, and to the extent possible, natural flow regimes in the rivers,
- Collect additional data to determine the frequency, duration, and spatial extent of low flow conditions and assess habitat quality as it is related to streamflow,
- The following facilities should collect river water upstream of their discharges to use as dilution water in their whole effluent toxicity tests: Grafton WWTP, Northbridge WWTP, Uxbridge WWTF, Upton WWTF, Hopedale WWTP and the New England Plating Company. If the river water does not meet the control test acceptability criteria (i.e., survival > 80% at 7-day exposure), then it should be utilized in the whole effluent toxicity test as a site control but not used as the diluent,
- Toxicity Identification Evaluations and Toxicity Reduction Evaluations (TIE/TREs) should be conducted at facilities that either frequently and/or severely violate their whole effluent toxicity permit limits,
- Reissue the remaining municipal and industrial NPDES permits in the Blackstone River Basin with appropriate permit limits and monitoring requirements,
- Continue to implement remedial actions that will clean up contaminated groundwater, sediments, and soil in the Blackstone River Basin,
- In the next revision of the SWQS designate various rivers as Cold Water Fisheries (if supported by Division of Fisheries, Wildlife, and Environmental Law Enforcement - DFWELE), and
- Continue to support the US Army Corps of Engineers Aquatic Habitat Restoration Study ongoing in the Blackstone River Basin.

The municipal NPDES permits will address phosphorus loading to the watershed in an attempt to reduce nutrient loading to the Blackstone River (and ultimately to Narragansett Bay). The need to control phosphorus and nitrogen loads will be refined during the upcoming development of the TMDL, which will be the culmination of the decade long Blackstone River Project which began in the 1990s. The city of Worcester is developing a long-range control plan that addresses abatement of impacts related to CSOs. Implementation of the requirements of the city's storm water permit will also be incorporated into this plan. Additionally, several communities including Auburn, Blackstone, Grafton, Millbury, Millville, Northbridge, Shrewsbury, Sutton, and Uxbridge will be required to obtain Phase II storm water permits to reduce impacts of storm water to the river by the development of BMPs, elimination of cross-connections and significant public education.

## BLACKSTONE RIVER BASIN - LAKES

Information on 138 of the 188 lakes (73%) in the Blackstone River Basin is presented in this report. These lakes represent approximately 95% (6,743.6 of 7,086.6 acres) of the basin's total lake acreage. In cases where the dam control structure was breached or aquatic plant density reduced ponds to channels and marshlands the designated uses were considered non-attainable due to the perennial 'loss' of pond acreage. DWM synoptic surveys in 1994 found this to be the case for six lakes (Forge, Mayo, Merrill No.6, Middle River, Thompson, Williams Street ponds) and portions of four lakes (City Farm Pond, Curtis Pond south basin, Rice City Pond and Sibley Reservoir) totaling 175 acres in the Blackstone River Basin. Therefore, the actual assessed lake-acreage is 6,568.6 acres (6,743.6 less 175 not attainable acres).

Lakes in the Blackstone River Basin represent all stages of succession, as described in terms of trophic status estimates (Table 1). Excessive plant growth in lakes (both rooted aquatics and algae) was the most frequently recorded cause of impairment for multiple uses (*Aquatic Life, Primary* and *Secondary Contact Recreation* and *Aesthetics*).

Table 1. Blackstone River Basin 1998 lake trophic status summary.

| TROPHIC STATUS | NUMBER OF LAKES | ACRES |
|---|---|---|
| Oligotrophic | 5 | 639.0 |
| Mesotrophic | 29 | 2,333.0 |
| Eutrophic | 78 | 2,791.6 |
| Hypereutrophic | 11 | 288.0 |
| Undetermined* | 9 | 517.0 |
| Not Attainable | 6 entire (and portions of 4) | 175.0 |
| Total | 138 | 6,743.6 |

* It should be noted that some lakes or portions of lakes are listed as undetermined when indicators were not readily observable. With this approach, only the most obvious impairments are reported and so the assessment of lakes in the Blackstone River Basin is limited to a "best case" picture. Potentially more of the lake acreage would be listed as impaired, or in a more enriched trophic status, if more variables were measured and more criteria assessed.

### *AQUATIC LIFE USE – LAKES*

The status of the *Aquatic Life Use* for the Blackstone River Basin lakes (acres) is as follows:

| ***Aquatic Life Use* Summary – Lakes (acres)** | | | |
|---|---|---|---|
| SUPPORT | PARTIAL SUPPORT | NON-SUPPORT | NOT ASSESSED |
| 0 | 3,277.6 | 171.0 | 3,120.0 |

Four non-native aquatic plant species (Eurasian water milfoil, variable milfoil, bushy pondweed, and fanwort) were found in lakes in the Blackstone River Basin. These plants are particularly invasive species and reproduce vegetatively; so they may spread readily on downstream currents or between lakes by mechanical transport. Based on the presence of these non-native aquatic species, 53 lakes were assessed as partial or non-support for the *Aquatic Life Use*. Approximately half of the lake-acreage was not assessed for this use.

### *FISH CONSUMPTION USE – LAKES*

The status of the *Fish Consumption Use* for the Blackstone River Basin lakes is as follows:

| ***Fish Consumption Use* Summary – Lakes (acres)** | | | |
|---|---|---|---|
| SUPPORT | PARTIAL SUPPORT | NON-SUPPORT | NOT ASSESSED |
| 0 | 0 | 94.0 | 6,474.6 |

Because of health concerns associated with exposure to mercury, DPH issued a fish consumption advisory for Waite Pond in Leicester (MA DPH 1999). DPH issued fish consumption advisories because

of PCB contamination for Riverdale Pond in Northbridge, Rice City Pond in Uxbridge/Northbridge (impoundments of the Blackstone River) and Spindleville Pond in Hopedale (an impoundment of the Mill River) (MA DPH 1999). Because of these advisories, the *Fish Consumption Use* was assessed as non-support for 94 of the 6,568.6 lake-acres in the Blackstone River Basin. The remaining acreage was not assessed because of DPH's statewide interim advisory for mercury (see *Fish Consumption Use – Rivers*) that encompasses all freshwater in Massachusetts.

### *DRINKING WATER USE – LAKES*

The *Drinking Water Use* has been used to indicate sources of public drinking water. While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at http://www.state.ma.us/dep/brp/dws/dwshome.htm and from the Blackstone River Basin's public water suppliers. These waters are subject to stringent regulation in accordance with the Massachusetts Drinking Water Regulations. The DWP has primacy for implementing the provisions of the federal Safe Drinking Water Act. DWP has also initiated work on SWAP which requires that the state delineate protection areas for all public ground and surface water sources; inventory land uses in these areas that may present potential threats to drinking water quality; determine the susceptibility of water supplies to contamination from these sources; and publicize the results. Except for Suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality) public water suppliers monitor their finished water (tap water) for major categories of contaminants (e.g., bacteria, volatile and synthetic organic compounds, inorganic compounds, etc.) and report their data to DWP.

### *PRIMARY CONTACT RECREATIONAL USE - LAKES*

The status of *Primary Contact Recreational Use* in the Blackstone River Basin lakes is as follows:

| ***Primary Contact Recreational Use* Summary – Lakes (acres)** | | | |
|---|---|---|---|
| SUPPORT | PARTIAL SUPPORT | NON-SUPPORT | NOT ASSESSED |
| 0 | 490.0 | 1,322.0 | 4,756.6 |

None of the lakes in the Blackstone River Basin were assessed as support for the *Primary Contact Recreational Use* while all or portions of 83 lakes (1,812 acres) were impaired (partial or non-support) for this use. Because of the focus of the surveys conducted (macrophyte cover, transparency and biocommunity modifications), the major causes of impairment included noxious/overabundant plant growth (both native and non-native vegetation), taste/odor/color, and/or objectionable turbidity. This use was not assessed for the majority (72%) of the lake-acreage in the Blackstone River Basin.

### *SECONDARY CONTACT RECREATIONAL AND AESTHETICS USES – LAKES*

The status of *Secondary Contact Recreational* and *Aesthetics* uses in the Blackstone River Basin lakes is as follows:

| ***Secondary Contact Recreational* and *Aesthetics* use Summary – Lakes (acres)** | | | |
|---|---|---|---|
| SUPPORT | PARTIAL SUPPORT | NON-SUPPORT | NOT ASSESSED |
| 2,560.0 | 490.0 | 1,322.0 | 2,196.6 |

The *Secondary Contact Recreational* and *Aesthetics* uses were assessed as support in all or portions of 38 lakes (2,560 acres). These uses were impaired (partial or non-support), however, in all or portions of 83 lakes (1,812 acres). Because of the focus of the surveys conducted (macrophyte cover, transparency and biocommunity modifications), the major causes of impairment included noxious/overabundant plant growth (both native and non-native vegetation), taste/odor/color, and/or objectionable turbidity. Approximately one-third of the lake-acreage in the Blackstone River Basin was not assessed for the *Secondary Contact Recreational* and *Aesthetics* uses.

**SUMMARY - LAKES**

Potentially more of the lake acreage would be listed as impaired or in a more enriched trophic status if additional variables were measured and more criteria assessed. In the Blackstone River Basin there is a need to:

- conduct monitoring for fecal coliform bacteria and Secchi disk depth to assess the *Primary Contact Recreational Use*,
- conduct monitoring for water chemistry data including dissolved oxygen and temperature profiles, total phosphorus and chlorophyll *a* to assess the *Aquatic Life Use*,
- monitor/control the spread and growth of non-native aquatic and wetland vegetation,
- implement recommendations identified in the TMDLs and lake Diagnostic/Feasibility studies, including lake watershed surveys to identify sources of impairment, and
- review the DEP Drinking Water Program SWAP evaluations are when they are completed to develop and implement recommendations for the protection of Class A lakes in the Blackstone River Basin .including Holden Reservoirs #1 and 2, Kettle Brook Reservoirs #1-4, Lynde Brook Reservoir, Miscoe and Wallum lakes, and Southwick Pond.

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# INTRODUCTION

The Massachusetts Watershed Initiative is a collaborative effort between state and federal environmental agencies, municipal agencies, citizens, non-profit groups, businesses and industries in the watershed. The mission is to improve water quality conditions and to provide a framework under which the restoration and/or protection of the basin's natural resources can be achieved. Implementation of this project is underway in a process known as the "Watershed Approach". The five-year cycle of the Watershed Approach, as illustrated in Figure 3, provides the management structure to carry out the mission. This report presents the current assessment of water quality conditions in the Blackstone River Basin. The assessment is based on information that has been researched and developed through the first three years (information gathering, monitoring, and assessment) of the five-year cycle by the Department of Environmental Protection (DEP) as part of its federal mandate under the Federal Water Pollution Control Act (commonly known as the Clean Water Act).

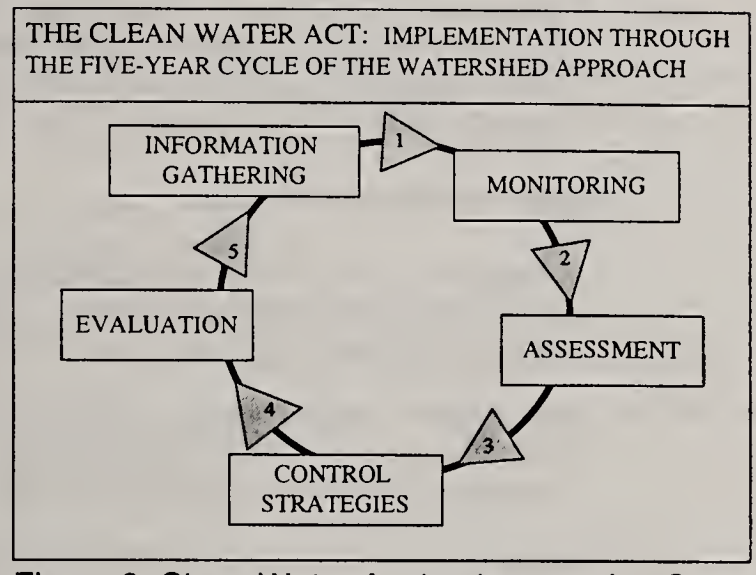

Figure 3. Clean Water Act Implementation Cycle

The objective of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Environmental Law Reporter 1988). To meet this goal, the CWA requires states to develop information on the quality of the Nation's water resources and report this information to the U.S. Environmental Protection Agency (EPA), the U.S. Congress, and the public. Together, these agencies are responsible for implementation of the CWA mandates. Under Section 305(b) of the Federal Clean Water Act, DEP must submit a statewide report every two years to the EPA, which describes the status of water quality in the Commonwealth. The most recent 305(b) report is the *Commonwealth of Massachusetts Summary of Water Quality 2000* (MA DEP 2000b). The 305(b) statewide report is based on the compilation of information for the Commonwealth's 27 watersheds. The 305(b) report compiles data from a variety of sources, and provides an evaluation of water quality, progress made towards maintaining and restoring water quality, and the extent to which problems remain at the statewide level. At the watershed level, instream biological, habitat, physical/chemical, toxicity data and other information is evaluated to assess the status of water quality conditions. This analysis follows a standardized process described below (Assessment Methodology).

## ASSESSMENT METHODOLOGY

## WATER QUALITY CLASSIFICATION

The Massachusetts Surface Water Quality Standards (SWQS) designate the most sensitive uses for which the surface waters of the Commonwealth shall be enhanced, maintained and protected; prescribe minimum water quality criteria required to sustain the designated uses; and include provisions for the prohibition of discharges (MA DEP 1996). These regulations should undergo public review every three years. The surface waters are segmented and each segment is assigned to one of the six classes described below. Each class is identified by the most sensitive, and therefore governing, water uses to be achieved and protected. Surface waters may be suitable for other beneficial uses, but shall be regulated by the Division to protect and enhance the designated uses.

### Inland Water Classes

1. ***Class A*** *– These waters are designated as a source of public water supply. To the extent compatible with this use they shall be an excellent habitat for fish, other aquatic life* and *wildlife,* and *suitable for primary* and *secondary contact recreation. These waters shall have excellent aesthetic value. These waters are designated for protection as Outstanding Resource Waters (ORW's) under 314 CMR 4.04(3).*

2. ***Class B*** – *These waters are designated as a habitat for fish, other aquatic life,* and *wildlife,* and *for primary* and *secondary contact recreation. Where designated they shall be suitable as a source of water supply with appropriate treatment. They shall be suitable for irrigation* and *other agricultural uses* and *for compatible industrial cooling* and *process uses. These waters shall have consistently good aesthetic value.*

3. ***Class C*** – *These waters are designated as a habitat for fish, other aquatic life* and *wildlife,* and *for secondary contact recreation. These waters shall be suitable for the irrigation of crops used for consumption after cooking* and *for compatible industrial cooling* and *process uses. These waters shall have good aesthetic value.*

### Coastal and Marine Classes

4. ***Class SA*** – *These waters are designated as an excellent habitat for fish, other aquatic life* and *wildlife* and *for primary* and *secondary recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfishing Areas). These waters shall have excellent aesthetic value.*

5. ***Class SB*** – *These waters are designated as a habitat for fish, other aquatic life* and *wildlife* and *for primary* and *secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfishing Areas). These waters shall have consistently good aesthetic value.*

6. ***Class SC*** – *These waters are designated as a habitat for fish, other aquatic life,* and *wildlife* and *for secondary contact recreation. They shall also be suitable for certain industrial cooling* and *process uses. These waters shall have good aesthetic value.*

The CWA Section 305(b) water quality reporting process is an essential aspect of the Nation's water pollution control effort. It is the principal means by which EPA, Congress, and the public evaluate existing water quality, assess progress made in maintaining and restoring water quality, and determine the extent of remaining problems. In so doing, the States report on waterbodies within the context of meeting their designated uses (described above in each class). Each class is identified by the most sensitive, and therefore governing, water uses to be achieved and protected. These uses include: *Aquatic Life, Fish Consumption, Drinking Water, Primary* and *Secondary Contact Recreation, Shellfishing* and *Aesthetics.* Three subclasses of Aquatic Life are also designated in the standards: Cold Water Fishery (capable of sustaining a year-round population of cold water aquatic life such as trout), Warm Water Fishery (waters which are not capable of sustaining a year-round population of cold water aquatic life), and Marine Fishery (suitable for sustaining marine flora and fauna).

The SWQS, summarized in Table 2, prescribes minimum water quality criteria to sustain the designated uses. Furthermore these standards describe the hydrological conditions at which water quality criteria must be met (MA DEP 1996). In rivers, the lowest flow conditions at and above which criteria must be met is the lowest mean flow for seven consecutive days to be expected once in ten years (7Q10). In artificially regulated waters, the lowest flow conditions at which criteria must be met is the flow equal or exceeded 99% of the time on a yearly basis or another equivalent flow which has been agreed upon. In coastal and marine waters and for lakes the most severe hydrological condition is determined by DEP on a case-by-case basis.

The availability of appropriate and reliable scientific data and technical information is fundamental to the 305(b) reporting process. It is EPA policy (EPA Order 5360.1 CHG 1) that any organization performing work for or on behalf of EPA establish a Quality System to support the development, review, approval, implementation, and assessment of data collection operations. To this end, DEP describes its Quality System in an EPA-approved Quality Management Plan to ensure that environmental data collected or compiled by the Agency are of known and documented quality and are suitable for their intended use. For external sources of information, DEP requires the following: 1) an appropriate *Quality Assurance Project Plan* including a QA/QC plan, 2) use of a state certified lab (certified in the applicable analysis), 3) data management QA/QC be described, and 4) the information be documented in a citable report.

Table 2. Summary of Massachusetts Surface Water Quality Standards (MA DEP 1996). *Note*: *Italics are direct quotations*.

| | |
|---|---|
| Dissolved Oxygen | Class A, BCWF*, SA : ≥ 6.0 mg/L and ≥ 75% saturation unless background conditions are lower<br>Class BWWF**, SB: ≥ 5.0 mg/L and ≥ 60% saturation unless background conditions are lower<br>Class C: Not ≤ 5.0 mg/L for more than 16 of any 24 –hour period and not ≤ 3.0 mg/L anytime unless background conditions are lower; levels cannot be lowered below 50% saturation due to a discharge<br>Class SC: Not ≤ 5.0 mg/L for more than 16 of any 24 –hour period and not ≤ 4.0 mg/L anytime unless background conditions are lower; and 50% saturation; levels cannot be lowered below 50% saturation due to a discharge |
| Temperature | Class A: ≤ 68°F (20°C) and Δ 1.5°F (0.8°C) for Cold Water and ≤ 83°F (28.3°C) and Δ 1.5°F (0.8°C) for Warm Water<br>Class BCWF: ≤ 68°F (20°C) and Δ3°F (1.7°C) due to a discharge<br>Class BWWF: ≤ 83°F (28.3°C) and Δ3°F (1.7°C) in lakes, Δ5°F (2.8°C) in rivers<br>Class C, SC: ≤85°F (29.4°C) nor Δ5°F (2.8°C) due to a discharge<br>Class SA: ≤85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C) and Δ1.5°F (0.8°C)<br>Class SB: ≤85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C) and Δ1.5°F (0.8°C) between July through September and Δ 4.0°F (2.2°C) between October through June |
| pH | Class A, BCWF, BWWF: 6.5 – 8.3 and Δ0.5 outside the background range.<br>Class C: 6.5 – 9.0 and Δ1.0 outside the naturally occurring range.<br>Class SA, SB: 6.5 – 8.5 and Δ0.2 outside the normally occurring range.<br>Class SC: 6.5 – 9.0 and Δ0.5 outside the naturally occurring range. |
| Fecal Coliform Bacteria (Class A criteria applied to the drinking water use, Class B criteria applied to primary and secondary contact recreational uses) | Class A: an arithmetic mean of < 20 organisms /100 mL in any representative set of samples and < 10% of the samples > 100 organisms/100 mL.<br>Class B: a geometric mean of < 200 organisms /100 mL in any representative set of samples and < 10% of the samples > 400 organisms /100 mL. (This criterion can be applied on a seasonal basis at the discretion of the DEP.)<br>Class C: a geometric mean of < 1000 organisms /100ml, and < 10% of the samples > 2000 organisms/100 mL.<br>Class SA: approved Open Shellfish Areas: a geometric mean (MPN method) of < 14 organisms/100 mL and < 10% of the samples > 43 organisms/100 mL (MPN method).<br>Waters not designated for shellfishing: < a geometric mean of 200 organisms in any representative set of samples, and < 10% of the samples > 400 organisms /100 mL. (This criterion can be applied on a seasonal basis at the discretion of the DEP.)<br>Class SB: approved Restricted Shellfish Areas: < a fecal coliform median or geometric mean (MPN method) of 88 organisms/100 mL and < 10% of the samples > 260 organisms /100 mL (MPN method).<br>Waters not designated for shellfishing: < a geometric mean of 200 organisms in any representative set of samples, and < 10% of the samples > 400 organisms /100 mL. (This criterion can be applied on a seasonal basis at the discretion of the DEP.)<br>Class SC: < a geometric mean of 1000 organisms/100 mL and < 10% of the samples > 2000 organisms/100ml. |
| Solids | All Classes: *These waters shall be free from floating, suspended,* and *settleable solids in concentrations or combinations that would impair any use assigned to each class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.* |
| Color and Turbidity | All Classes: *These waters shall be free from color* and *turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use.* |
| Oil & Grease | Class A, SA: *Waters shall be free from oil* and *grease, petrochemicals* and *other volatile or synthetic organic pollutants.*<br>Class SA: *Waters shall be free from oil* and *grease* and *petrochemicals.*<br>Class B, C,SB, SC: *Waters shall be free from oil* and *grease, petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course or are deleterious or become toxic to aquatic life.* |
| Taste and Odor | Class A, SA: *None other than of natural origin.*<br>Class B, C,SB, SC: *None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to each class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.* |
| Aesthetics | All Classes: *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.* |
| Toxic Pollutants ~ | All Classes: *All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife… The division shall use the recommended limit published by EPA pursuant to 33 USC 1251, 304(a) as the allowable receiving water concentrations for the affected waters unless a site-specific limit is established.* |
| Nutrients | *Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.* |

*Class BCWF = Class B Cold Water Fishery, ** Class BWWF = Class B Warm Water Fishery, Δ criterion (referring to a change from ambient) is applied to the effects of a permitted discharge. ~ USEPA. 19 November 1999. Federal Register Document. [Online]. United States Environmental Protection Agency. http://www.epa.gov/fedrgstr/EPA-WATER/1998/December/Day-10/w30272.htm.

EPA provides guidelines to the States for making their use support determinations (US EPA 1997). The determination of whether or not a waterbody supports each of its designated uses is a function of the type(s), quality and quantity of available current information. Although data/information older than five years are usually considered "historical" and used for descriptive purposes, they can be utilized in the use support determination providing they are known to reflect the current conditions. While the water quality standards (Table 2) prescribe minimum water quality criteria to sustain the designated uses, numerical criteria are not available for every indicator of pollution. Best available guidance in the literature may be applied in lieu of actual numerical criteria (e.g., freshwater sediment data may be compared to *Guidelines for the Protection* and *Management of Aquatic Sediment Quality in Ontario* 1993 by D. Persaud, R. Jaagumagi and A. Hayton). Water quality conditions that do not meet criteria but are "naturally occurring" (e.g., low pH in some areas) do not constitute violations of the standards.

Each designated use within a given segment is individually assessed as 1) ***support***, 2) ***partial support***, or 3) ***non-support***. The term ***threatened*** is used when the use is fully supported but may not support the use within two years because of adverse pollution trends or anticipated sources of pollution. When too little current data/information exists or no reliable data are available the use is ***not assessed.*** In this report, however, if there is some indication that water quality impairment may exist which is not "naturally occurring", the use is identified with an "Alert Status". Detailed guidance for assessing the status of each use follows in the Designated Uses Section of this report. It is important to note, however, that not all waters are assessed. Many small and/or unnamed lakes, rivers, and estuaries are currently ***unassessed***; the status of their designated uses has never been reported to EPA in the state's 305(b) Report nor is information on these waters maintained in the Water Body System (WBS) database.

## DESIGNATED USES

The Massachusetts Surface Water Quality Standards designate the most sensitive uses for which the surface waters of the Commonwealth shall be enhanced, maintained and protected. Each of these uses is briefly described below (MA DEP 1996):

- AQUATIC LIFE - suitable habitat for sustaining a native, naturally diverse, community of aquatic flora and fauna. Three subclasses of aquatic life are also designated in the standards for freshwater bodies; *Cold Water Fishery* - capable of sustaining a year-round population of cold water aquatic life such as trout, *Warm Water Fishery* - waters which are not capable of sustaining a year-round population of cold water aquatic life, and *Marine Fishery* - suitable for sustaining marine flora and fauna.

- FISH CONSUMPTION - pollutants shall not result in unacceptable concentrations in edible portions of marketable fish or shellfish or for the recreational use of fish, shellfish, other aquatic life or wildlife for human consumption.

- DRINKING WATER - used to denote those waters used as a source of public drinking water. They may be subject to more stringent regulation in accordance with the Massachusetts Drinking Water Regulations (310 CMR 22.00). These waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3).

- PRIMARY CONTACT RECREATION - suitable for any recreation or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water. These include, but are not limited to, wading, swimming, diving, surfing and water skiing.

- SECONDARY CONTACT RECREATION - suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities.

- AESTHETICS - all surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

- AGRICULTURAL AND INDUSTRIAL - suitable for irrigation or other agricultural process water and for compatible industrial cooling and process water.

Other restrictions which denote specific subcategories of use assigned to the segment that may affect the application of criteria or specific antidegradation provision of 314 CMR 4.00 which are specified along segments in the Chicopee River Basin:

- Combined Sewer Overflow (CSO) – These waters are identified as impacted by the discharge of combined sewer overflows in the classification tables in 314 CMR 4.06(3). Overflow events may be allowed by the permitting authority without a variance or partial use designation where the provisions 314 CMR 4.06(1)(d)10 are met. The waterbody may be subject to short-term impairment of swimming or other recreational uses, but support these uses through most of their annual period of use; and the aquatic life community may suffer some adverse impact yet is still generally viable).

  [Note: The SWQS have "CSO" listed where CSOs impacts occur. However, this is only a notation and does not have regulatory significance unless all of the provisions of 314 CMR 4.06 (1) (d) 10. have been met (Facilities Plan Approval, Use Attainability Analysis, etc.) and DEP makes a formal administrative determination after a public hearing and MEPA filing that a B(CSO) designation is supported and appropriate (Brander 2001).]

The guidance used to assess the *Aquatic Life, Fish Consumption, Drinking Water, Primary* and *Secondary Contact Recreation* and *Aesthetics* uses follows.

## *AQUATIC LIFE USE*

This use is suitable for sustaining a native, naturally diverse, community of aquatic flora and fauna. The results of biological (and habitat), toxicological, and chemical data are integrated to assess this use. The nature, frequency, and precision of the DEP's data collection techniques dictate that a weight of evidence be used to make the assessment, with biosurvey results used as the final arbiter of borderline cases. The following chart provides an overview of the guidance used to assess the status (support, partial support, non-support) of the *Aquatic Life Use*:

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – Data available clearly indicates support. Minor excursions from chemical criteria (Table 2) may be tolerated if the biosurvey results demonstrate support. | ***Partial Support*** – Uncertainty about support in the chemical or toxicity testing data, or there is some minor modification of the biological community. Excursions not frequent or prolonged. | ***Non-Support*** – There are frequent or severe violations of chemical criteria, presence of acute toxicity, or a moderate or severe modification of the biological community. |
|---|---|---|---|
| **BIOLOGY** | | | |
| Rapid Bioassessment Protocol (RBP) II or III (4) | Non-Impaired | Slightly Impaired | Moderately or Severely Impaired |
| Fish Community (4) | Best Professional Judgement (BPJ) | BPJ | BPJ |
| Habitat and Flow (4) | BPJ | BPJ | Dewatered Streambed due to artificial regulation or channel alteration |
| Macrophytes (4) | BPJ | Non-native plant species present, but not dominant, BPJ | Non-native plant species dominant, BPJ |
| Plankton/ Periphyton (4) | No algal blooms | Occasional algal blooms | Persistent algal blooms |
| **TOXICITY TESTS** | | | |
| Water Column/Ambient (4) | >75% survival either 48 hr or 7-day exposure | >50 - ≤75% survival either 48 hr or 7-day exposure | ≤50% survival either 48 hr or 7-day exposure |
| Effluent (4) | Meets permit limits | (NOTE: if limit is not met, the stream is listed as threatened for 1.0 river mile downstream from the discharge.) | |
| Sediment (4) | >75% survival | >50 - ≤75% survival | ≤50% survival |
| **CHEMISTRY- WATER** | | | |
| DO (3, 6) | Criteria (Table 2) | Criteria exceed in 11-25% of measurements. | Criteria exceeded >25% of measurements. |
| pH (3, 6) | Criteria (Table 2) | Criteria exceed in 11-25% of measurements. | Criteria exceeded >25% of measurements. |
| Temperature (3, 6) [1] | Criteria (Table 2), [1] | Criteria exceed in 11-25% of measurements. | Criteria exceeded >25% of measurements. |
| Turbidity (4) | Δ 5 NTU due to a discharge | BPJ | BPJ |
| Suspended Solids (4) | 25 mg/L max., Δ10 mg/L due to a discharge | BPJ | BPJ |
| Nutrients (3)<br>Phosphate-P (4) | Table 2, (Site-Specific Criteria; Maintain Balanced Biocommunity, no pH/DO violations) | BPJ | BPJ |
| Toxic Pollutants (3, 6)<br>Ammonia-N (3, 4) [2]<br>Chlorine (3, 6) [3] | Criteria (Table 2)<br>0.254 mg/L $NH_3$-N [2]<br>0.011 mg/L TRC[3] | BPJ | Criterion is exceed in > 10% of samples. |
| **CHEMISTRY – SEDIMENT** | | | |
| Toxic Pollutants (5) [4] | ≤ L-EL[4], Low Effect Level | One pollutant between L-EL and S-EL | One pollutant ≥ S-EL (severe) |
| Nutrients (5) | ≤ L-EL | between L-EL and S-EL | ≥ S-EL |
| Metal Normalization to Al or Fe (4) | Enrichment Ratio ≤ 1 | Enrichment Ratio >1 but ≤10 | Enrichment Ratio ≥10 |
| **CHEMISTRY- EFFLUENT** | | | |
| Compliance with permit limits (4) | In-compliance with all limits | NOTE: If the facility does not meet their permit limits, the information is used to threaten one river mile downstream from the discharge. | |
| **CHEMISTRY-TISSUE** | | | |
| PCB – whole fish (1) | ≤500 µg/kg wet weight | BPJ | BPJ |
| DDT (2) | ≤14.0 µg/kg wet weight | BPJ | BPJ |
| PCB in aquatic tissue (2) | ≤0.79 ng TEQ/kg wet weight | BPJ | BPJ |

[1] maximum daily mean T in a month (min 6 measurements evenly distributed over 24-hours) <criterion, [2] Ammonia levels for pH of 9.0, actual "criterion" varies with pH and is evaluated case-by-case. During DWM's Chicopee 1998 survey the max pH was 7.9 SU resulting in an ambient criterion for ammonia-N of 1.46mg/L. [3] The minimum quantification level for TRC is 0.05 mg/L. [4] For the purpose of this report, the S-EL for total PCB in sediment (which varies with TOC content) with 1% TOC is 5.3 PPM while a sediment sample with 10% TOC is 53ppm.

Note: The NAS/NAE guideline for maximum organochlorine concentrations (i.e., total PCB) in fish tissue for the protection of fish-eating wildlife is 500µg/kg wet weight (PPB, not lipid-normalized). PCB data (tissue) in this report are presented in µg/kg wet weight (PPB) and are not lipid-normalized to allow for direct comparison to the NAS/NAE guideline.

## *FISH CONSUMPTION USE*

Pollutants shall not result in unacceptable concentrations in edible portions of marketable fish or shellfish or for the recreational use of fish, shellfish, other aquatic life or wildlife for human consumption. The assessment of this use is made using the most recent list of Fish Consumption Advisories issued by the Massachusetts Executive Office of Health and Human Services, Department of Public Health (DPH), Bureau of Environmental Health Assessment (MA DPH 1999). The DPH list identifies waterbodies where elevated levels of a specified contaminant in edible portions of freshwater species poses a health risk for human consumption; hence the *Fish Consumption Use* is assessed as non-support in these waters. In 1994, DPH also issued a statewide "Interim Freshwater Fish Consumption Advisory" for mercury (MA DPH 1994). This precautionary measure was aimed at pregnant women only; the general public was not considered to be at risk from fish consumption. DPH's interim advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially. Because of the statewide interim advisory, however, no fresh waters can be assessed as support or partial support for the *Fish Consumption Use*. The following is an overview of the guidance used to assess the status (support, partial support, non-support) of the *Fish Consumption Use*.

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – No restrictions or bans in effect | ***Partial Support*** – A "restricted consumption" fish advisory is in effect for the general population or a sub-population that could be at potentially greater risk (e.g., pregnant women, and children | ***Non-Support*** – A "no consumption" advisory or ban in effect for the general population or a sub-population for one or more fish species; or there is a commercial fishing ban in effect |
|---|---|---|---|
| DPH Fish Consumption Advisory List (8) | Not applicable, precluded by statewide advisory (Hg) | Not applicable | Waterbody on DPH Fish Consumption Advisory List |

## *DRINKING WATER USE*

The term *Drinking Water Use* denotes those waters used as a source of public drinking water. These waters may be subject to more stringent regulation in accordance with the Massachusetts Drinking Water Regulations (310 CMR 22.00). They are designated for protection as Outstanding Resource Waters in 314 CMR 4.04(3). DEP's Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act (SDWA). Except for Suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality) all public drinking water supplies are monitored as finished water (tap water). Monitoring includes the major categories of contaminants established in the SDWA: bacteria, volatile and synthetic organic compounds, inorganic compounds and radionuclides. The DWP maintains current drinking supply monitoring data. The status of the supplies is currently reported on a statewide basis to EPA in the 305(b) report. Below is EPA's guidance to assess the status (support, partial support, non-support) of the drinking water use.

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – No closures or advisories (no contaminants with confirmed exceedances of MCLs*, conventional treatment is adequate to maintain the supply). | ***Partial Support*** – Is one or more advisories or more than conventional treatment is required | ***Non-Support*** -- One or more contamination-based closures of the water supply |
|---|---|---|---|
| Drinking Water Program (DWP) Evaluation | See note below | See note below | See note below |

*MCLs = maximum contaminant levels

Note: While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at http://www.state.ma.us/dep/brp/dws/dwshome.htm and from the Blackstone River Basin's public water suppliers.

## *PRIMARY CONTACT RECREATIONAL USE*

This use is suitable for any recreational or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water (1 April to 15 October). These include, but are not limited to, wading, swimming, diving, surfing and water skiing. The chart below provides an overview of the guidance used to assess the status (support, partial support, non-support) of the *Primary Contact Use*.

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – Criteria are met, no aesthetic conditions that preclude the use | ***Partial Support*** – Criteria exceeded intermittently (neither frequent nor prolonged), marginal aesthetic violations | ***Non-Support*** – Frequent or prolonged violations of criteria, formal bathing area closures, or severe aesthetic conditions that preclude the use |
|---|---|---|---|
| Fecal Coliform Bacteria (3, 9) * | Criteria met OR<br>Dry Weather Guidance<br><5 samples--≤400/100 mL maximum<br>Wet Weather Guidance<br>Dry weather samples meet and wet samples ≤2000/100 mL | Guidance exceeded in 11-25% of the samples OR<br>Wet Weather<br>Dry weather samples meet and wet samples >2000/100 mL | Guidance exceeded in > 25% of the samples |
| pH (3, 6) | Criteria exceeded in ≤10 % of the measurements | Criteria exceeded in 11-25% of the measurements | Criteria exceeded in >25% of the measurements |
| Temperature (3) | Criteria met | Criteria exceeded 11-25% of the time | Criteria exceeded 25% of the time |
| Color and Turbidity (3, 6) | BPJ, Δ 5 NTU (due to a discharge) exceeded in ≤10 % of the measurements | BPJ, Guidance exceeded in 11-25% of the measurements | BPJ, Guidance exceeded in >25% of the measurements |
| Secchi disk depth (10) ** | Lakes - ≥1.2 meters ( ≥ 4') | Infrequent excursions from the guidance | Frequent and/or prolonged excursions from the guidance |
| Oil & Grease (3) | Criteria met | BPJ, criteria exceeded 11-25% of the time | BPJ, criteria exceeded >25% of the time |
| Aesthetics (3)<br>Biocommunity (4)** | No nuisance organisms that render the water aesthetically objectionable or unusable, BPJ; Cover of macrophytes < 50% within any portion of the lake area at maximum extent of growth. | BPJ, Cover of macrophytes 50-75% within any portion of the lake area at maximum extent of growth. | BPJ, Cover of macrophytes >75 within any portion of the lake area at maximum extent of growth. |

Note: Excursions from criteria due to natural conditions are not considered impairment of use.

* Fecal coliform bacteria interpretations require additional information in order to apply this use assessment guidance. Small/limited datasets require an evaluation of survey conditions (i.e., interpretation of the amount of precipitation received in the subject region immediately prior to sampling and streamflow conditions) to determine whether the fecal coliform bacteria results are represent dry or wet weather/storm water runoff conditions. When larger data sets are available, the frequency of standards/guidance exceedances is calculated.

**Any portion of a lake exhibiting impairment of the *Primary Contact Recreation Use* (swimmable) because of macrophyte cover and/or transparency (Secchi disk depth) is assessed as either partial or non-support. If no fecal coliform bacteria data are available and the lake (entirely or in part) met the transparency (Secchi disk depth) and aesthetics guidance this use is not assessed.

## *SECONDARY CONTACT RECREATIONAL USE*

This use is suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities. Following is an overview of the guidance used to assess the status (support, partial support, non-support) of the *Secondary Contact Use*.

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – Criteria are met, no aesthetic conditions that preclude the use | ***Partial Support*** – Criteria exceeded intermittently (neither frequent nor prolonged), marginal aesthetic violations | ***Non-Support*** – Frequent or prolonged violations of criteria, or severe aesthetic conditions that preclude the use |
|---|---|---|---|
| Fecal Coliform Bacteria (4) * | Dry Weather Guidance<br><5 samples--≤2000/100 mL maximum<br>>5 samples--≤1000/100 mL geometric mean<br>≤ 10% samples ≥2000/100 mL<br>Wet Weather Guidance<br>Dry weather samples meet and wet samples ≤4000/100 mL | Wet Weather Guidance<br>Dry weather samples meet and wet samples >4000/100 mL | Criteria exceeded in dry weather |
| Oil & Grease (3) | Criteria met | Criteria exceeded 11-25% of the time, BPJ | Criteria exceeded >25% of the time, BPJ |
| Aesthetics (3) Biocommunity (4) ** | No nuisance organisms that render the water aesthetically objectionable or unusable, BPJ; Cover of macrophytes < 50% within any portion of the lake area at maximum extent of growth. | BPJ, Cover of macrophytes 50-75% within any portion of the lake area at maximum extent of growth. | BPJ, Cover of macrophytes >75 within any portion of the lake area at maximum extent of growth. |

Note: Excursions from criteria due to natural conditions are not considered impairment of use.

* Fecal coliform bacteria interpretations require additional information in order to apply this use assessment guidance. Small/limited datasets require an evaluation of survey conditions (i.e., interpretation of the amount of precipitation received in the subject region immediately prior to sampling and streamflow conditions) to determine whether the fecal coliform bacteria results are represent dry or wet weather/storm water runoff conditions. When larger data sets are available, the frequency of standards/guidance exceedances is calculated.

** In lakes if no fecal coliform data are available, macrophyte cover is the only criterion used to assess the *Secondary Contact Recreational Use*.

For the *Primary* and *Secondary Contact Recreational* uses the following steps are taken to interpret the fecal coliform bacteria results:

1. Identify the range of fecal coliform bacteria results,
2. Calculate the geometric mean (monthly, seasonally, or on dataset), (Note: the geometric mean is only calculated on datasets with >5 samples collected within a 30-day period.)
3. Calculate the % of sample results exceeding 400 cfu/100 mLs,
4. Determine if the samples were collected during wet or dry weather conditions (review precipitation and streamflow data),
   Dry weather can be defined as: No/trace antecedent (to the sampling event) precipitation that causes more than a slight increase in stream flow.
   Wet weather can be defined as: Precipitation antecedent to the sampling event that results in a marked increase in stream flow.
5. Apply the following to interpret dry weather data:
   ≤10% of the samples exceed criteria (step 2 and 3, above) assessed as Support,
   11-25% of the samples exceed criteria (step 2 and 3, above) assessed as Partial Support,
   >25% of the samples exceed criteria (step 2 and 3, above) assessed as Non-Support.

## *AESTHETICS USE*

All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life. The aesthetic use is closely tied to the public health aspects of the recreational uses (swimming and boating). Below is an overview of the guidance used to assess the status (support, partial support, non-support) of the *Aesthetics Use.*

| ***Variable*** (# indicates reference provided at the end of the designated use section) | ***Support*** – 1. No objectionable bottom deposits, floating debris, scum, or nuisances; 2. objectionable odor, color, taste or turbidity, or nuisance aquatic life | ***Partial Support*** – Objectionable conditions neither frequent nor prolonged | ***Non-Support*** – Objectionable conditions frequent and/or prolonged |
|---|---|---|---|
| Aesthetics (3)* Visual observation (4) | Criteria met | BPJ (spatial and temporal extent of degradation) | BPJ (extent of spatial and temporal degradation) |

* For lakes, the aesthetic use category is generally assessed at the same level of impairment as the more severely impaired recreational use category (*Primary* or *Secondary Contact*).

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# BLACKSTONE RIVER BASIN DESCRIPTION AND CLASSIFICATION

## DESCRIPTION

The Blackstone River (Figure 4) is formed in the City of Worcester by the confluence of the Middle River and Mill Brook. The mainstem flows generally southeast through Worcester, Millbury, Sutton, and Grafton to Fisherville Pond, where it converges with the Quinsigamond River. Below Fisherville Pond, the Blackstone River flows in a southerly direction through Northbridge, Uxbridge, Millville, and Blackstone and crosses for the first time into Rhode Island. Just south of the RI border, it is joined by the Branch River, turns north and re-enters Massachusetts for a short distance, then turns south again and enters Woonsocket RI. The Blackstone River Basin is bordered by the Chicopee River Basin to the northwest, the French River Basin to the southwest, the Concord River Basin to the northeast and by the Charles River Basin to the southeast. The north and south portions of the basin are bordered the Nashua River Basin and the state of Rhode Island, respectively. Major tributaries that discharge to the Blackstone River in Massachusetts include the Quinsigamond, West, and Mumford rivers. The Mill and Peters rivers join the Blackstone River in Rhode Island. There are 188 lakes in the Massachusetts portion of the basin which cover approximately 7,087 acres.

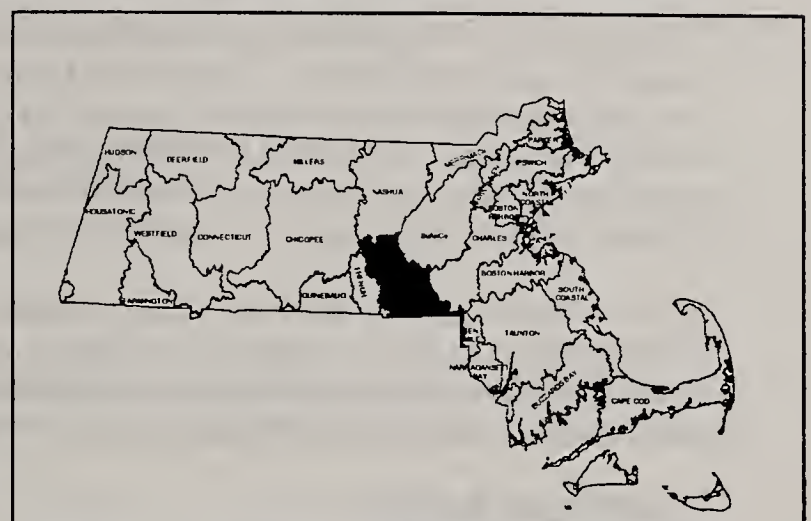


Figure 4. Location of Blackstone River Basin.

The mainstem Blackstone River is characterized by numerous impoundments formed by the remains of old mill-dams used historically for water power. In Massachusetts, two of these are still used at varying levels to generate power: Riverdale and Synergics (Tupperware). Water levels in the river fluctuate rapidly over short periods of time due to a combination of storm impacts and water flow regulations. The flow impacts during storm events are compounded by the predominance of impervious surfaces and the scarcity of wetlands. A decrease in impervious surfaces and an increase in wetlands would moderate flows through absorbing and releasing the water over larger time events.

The drainage area of the Blackstone River Basin encompasses a total of 540 square miles of which approximately 335 square miles lie in Massachusetts including portions of Bristol, Middlesex, Norfolk, and Worcester counties. The communities of Attleboro, Auburn, Bellingham, Blackstone, Boylston, Douglas, Franklin, Grafton, Holden, Hopedale, Hopkinton, Leicester, Milford, Millbury, Millville, Northbridge, Mendon, North Attleborough, Oxford, Paxton, Plainville, Shrewsbury, Sutton, Upton, Uxbridge, Webster, Westborough, West Boylston, Worcester, and Wrentham lie wholly or in part within the watershed boundaries.

The Blackstone River has a long history of pollution. The Blackstone Valley was the birthplace of the American textile industry. The construction of the Blackstone Canal, which extended from Narragansett Bay to Worcester, was finished in 1828. It was used through 1848, when the railroad became a quicker and cheaper method of transporting goods. A detailed description of the canal and its history can be found in the Blackstone River Valley Cultural Heritage and Land Management Plan (BRVNHCC 1989). The Blackstone River and its tributaries were the first to be polluted by waste discharges from textile mills. The river has been described as "the world's busiest river" and "industrial stream" during the nineteenth and twentieth centuries (Tennant *et al.* 1975). Gross sediment contamination also resulted from the discharges of heavy metals from plating operations, oil and grease from machine shops, dyes and prints from textile plants, organics and metals from tanneries, and other sources (McGinn 1981). Resuspension of contaminated sediments located behind many of the dams along the Blackstone River, however, remains a major concern (US EPA and MA DWPC undated).

The industrial pollution has declined but domestic wastes being discharged into the river have increased with the growing population of the valley. According to Tennant *et al.*, the city of Worcester is the single most

important factor in the pollution of the Blackstone River (1975). Not only is the flow of the Blackstone River adversely affected by extensive impervious surfaces (altered natural hydrology resulting in higher high flows and lower low flows) which contribute pollutants from nonpoint sources, the river also provides limited dilution for municipal and industrial wastewater discharges. Since 1963, thirty-six National Pollutant Discharge Elimination System (NPDES) discharges, representing both municipal and industrial operations in 11 towns, have ceased to discharge to the Blackstone River Basin (Hogan 2000).

Today, major municipal wastewater treatment plants are located in Worcester (Upper Blackstone Water Pollution Abatement District - UBWPAD), Northbridge, Upton, Douglas, Hopedale, Grafton and Uxbridge. The Millbury wastewater treatment plant will be decommissioned within the next few years and the wastewater will be sent to the UBWPAD for treatment. Nonpoint source pollution associated with urban and agricultural runoff, contaminated sediments, runoff and/or leachate from dumps, junkyards, gravel pits, and automobile graveyards also contributes to the basin's water quality problems.

With the exception of Worcester, all communities in the Blackstone River Basin rely on groundwater as their primary source of public supply (Izbicki 2000). By the year 2020, demand for water in the basin is expected to be 52 MGD, one-third greater than the demand in 1980. Most of this increase is expected to be supplied by increased groundwater withdrawals from aquifers in the eastern and northern parts of the basin.

## CLASSIFICATION

Consistent with the National Goal Uses of "fishable and swimmable waters," the classification of waters in the Blackstone River Basin according to the SWQS (314 CMR 4.0), include Class A and Class B waters, as described below.

### *Class A Public Water Supplies in the Blackstone River Basin*

As stated previously, Class A waters are designated for protection as Outstanding Resource Waters (ORWs). These include public drinking water supplies, vernal pools, and all surface waters within an Area of Critical Environmental Concern (ACEC). In the Blackstone watershed, registered and/or permitted Class A Public Water Supplies include (MA DEP 1996):

- Kettle Brook, source to dam at Reservoir #1,
- Kettle Brook Reservoir Nos. 1-4, source to outlets in Leicester and Paxton and those tributaries thereto,
- Lynde Brook Reservoir, source to outlet in Leicester and those tributaries thereto,
- Holden Reservoirs Nos. 1 and 2, source to outlet in Holden and those tributaries thereto, and
- All interstate surface waters that are public water supplies in Rhode Island from 1000 feet upstream of the state line.

At this time, there are 38 certified vernal pools (CVP) in the Blackstone River Basin (according to the CVP database with the Division of Fisheries and Wildlife, January 2001). These vernal pools are found in Bellingham, Douglas, Grafton, Millbury, North Attleborough, Northbridge, Shrewsbury, Sutton, Upton, Uxbridge, and Worcester. Species of special concern observed in these pools include the marbled salamander (*Ambystoma opacum*) and the spotted turtle (*Clemmys guttata*). Other obligate vernal pool species include the spotted salamander (*A. maculatum*), wood frog (*Rana sylvatica*), and fairy shrimp (Order Anostraca). Numerous facultative vernal pool species were also identified (Maher 2001).

Currently, there is one designated ACEC in the Blackstone River Basin: the Miscoe-Warren-Whitehall ACEC in Grafton, Upton and Hopkinton was officially accepted on 17July 2000. The ACEC encompasses approximately 8,700 acres, and drains to both the Blackstone and Concord watersheds. Approximately 89% of the ACEC consists of forest, non-forested wetlands, and open lands and farmland. Resources of these headwater streams include: high quality surface and groundwater; reproducing populations of native brook trout; unfragmented and diverse wildlife habitat, which are known to be home to five rare species; agriculture; forestry; and unique and highly significant archaeological and historical resources. (For more information see http://www.state.ma.us/dem/programs/acec/l-miscoe.htm).

***Class B Cold Water Fisheries in the Blackstone River Basin:***

- West River, source to the Upton STP (WWTP)

***Class B Warm Water Fisheries in the Blackstone River Basin:***

- Kettle Brook, from Dam at Reservoir # 1 to outlet of Curtis Pond
- Middle River, entire length
- Blackstone River, source to outlet of Fisherville Pond (CSO), and to the Rhode Island State Line
- Mill Brook, entire length (CSO)
- Quinsigamond River, entire length
- Mumford River, source to the confluence with the Blackstone River
- West River, from the Upton STP to the Blackstone River
- Mill River, entire length
- Beaver Brook, entire length
- Weasel Brook, entire length

Unlisted waters not otherwise designated in the SWQS are designated *Class B, High Quality Water.* According to the SWQS, where fisheries designations are necessary, they shall be made on a case-by-case basis.

## SUMMARY OF EXISTING CONDITIONS AND PERCEIVED PROBLEMS

[Adapted from: *The Blackstone River Watershed Resource Assessment and Management Report TMDL Phase 1, (*MA DEP and US EPA 1997*)* and *Blackstone River Initiative Comprehensive Assessment Report on Dry and Wet Weather and Modeling* (Wright *et al.* 1998).

The Massachusetts Department of Environmental Protection (DEP) has conducted numerous water quality surveys in the Blackstone River watershed since 1965. Over 30 reports have been published by the DEP on the river and watershed since that time. These reports are available for review at the DEP Division of Watershed Management office in Worcester.

The most significant and comprehensive study of the river began in 1990 as an interagency interstate study of the river system during dry and wet weather conditions. The project was a cooperative effort among the USEPA, the University of Rhode Island, and the Massachusetts DEP. The project conducted extensive activities from 1991-1994 as part of an integrated monitoring (biology, chemistry, and toxicity of water and sediments), modeling, and assessment project. Dry weather sampling was conducted during July, August, and October of 1991 at 15 mainstem stations as well as the six major tributaries in the watershed. Wet weather sampling was conducted in 1992 and 1993. Biological and habitat assessment work was conducted between 1991 and 1994. Sediment quality sampling was also conducted in 1991(whole sediment toxicity and pore water toxicity tests).

A number of reports and appendices were produced which summarized the efforts involved, the data collected, and the final analyses and recommendations. Assessment of the Blackstone River Initiative (BRI) data was completed in 1997 as applied to the Massachusetts river segments and agency programs with a proposed plan of action for remediation (MA DEP and US EPA 1997). Assessment of the complete MA and RI data appears in the draft study report. (Wright *et al.* 1998)

- *Blackstone River Initiative: Phase 1: Dry Weather Assessment Interim Report of Data 1991* (US EPA and MA DWPC undated);
- *Blackstone River Initiative Phase 1 Dry Weather Assessment Report of Data 1991 Appendices* (US EPA and MA DWPC undated);
- *Blackstone River Watershed: Resource Assessment and Management Report, TMDL Phase 1 (*MA DEP and US EPA 1997*);*
- *Blackstone River Initiative Comprehensive Assessment Report on Dry and Wet Weather and Modeling (*Wright *et al.* 1998*). Data and models included on CD.*
- *Blackstone River Watershed Dissolved Oxygen Wasteload Allocation for Massachusetts and Rhode Island, (*MA DEP, EPA and RIDEM 1997*).*

The information collected under the BRI was utilized to develop a wasteload allocation computer model for the entire river in both Massachusetts and Rhode Island. This computer model, detailed in the Blackstone River Initiative Comprehensive Assessment Report (Wright *et al.* 1998) was utilized by the states to develop NPDES permit limits for municipal facilities on the mainstem. The 1998 report entitled, *Blackstone River Wasteload Allocation Report*, details the process involved in the development of the NPDES permit limits

for the municipal dischargers on the mainstem in Massachusetts and Rhode Island, and provides the options for permit limits with changes to water quality instream. This material was then incorporated into a Draft Seasonal Low Flow TMDL for nutrients and organic enrichment on the mainstem (MA DEP 2000a).

Follow-up work was conducted during 1998 and focused on the areas that the Blackstone Initiative identified as either "hot spots" or needing further monitoring, specifically in the numerous headwater tributaries and on the West River (Hartman and Fiorentino 1999). These areas for study were further refined by the information contained in the DEP and EOEA Blackstone watershed preliminary assessment and management report.

Typically during storm events with greater than 0.5 inches of rain and/or during consecutive storms, the Worcester CSO (MA0102997) facility discharges wastewater and storm water into "Mill Brook", Worcester. Additionally, the headwaters of the Blackstone River have numerous stormdrains, and other nonpoint source inputs that all contribute to water quality degradation, during wet weather. The Upper Blackstone Water Pollution Abatement District (UBWPAD) (MA0102369) discharges just downstream of the confluence of the headwater streams, and downstream of the confluence with Mill Brook and the CSO.

The Blackstone River Initiative demonstrated significant toxicity in the upper reaches of the mainstem during storm events. The largest number of toxic endpoints during storm events were measured in the upper two miles. Water quality exceedances during dry weather were found in the numerous impoundments along the mainstem. During dry weather, high levels of chlorophyll, large diurnal fluctuations in dissolved oxygen and pH, and supersaturated oxygen levels during the afternoon indicated high levels of phosphorus and other nutrients. The report also indicated the toxicity of sediments, which have been deposited historically in the impoundments and in the riverbanks. These sediments are resuspended into the water column through scouring at high flows and during times in which the river flow rises and falls rapidly.

The tributaries sampled in 1991 demonstrated high levels of some metals. Two tributaries had problems with dissolved oxygen.

The Clean Water Act section 303(d) requires states to identify those waterbodies that are not meeting Surface Water Quality Standards (SWQS). Table 3 is a list of waterbodies in the Blackstone River Basin that are on the 1998 Massachusetts Section 303(d) list of waters (MA DEP 1999).

Table 3. Waterbodies in the Blackstone River Basin included on the 1998 303(d) list.

| 1998 303(d) Listed Waterbody | | Cause of Impairment |
|---|---|---|
| Blackstone River | American Steel Dam, Worcester to Fisherville Dam, Grafton | Unknown toxicity, priority organics (PCB), metals, unionized ammonia, chlorine, nutrients, organic enrichment/low DO, flow alteration, pathogens( fecal coliform bacteria), suspended solids, turbidity |
| | Fisherville Dam, Grafton to Rice City Pond, Uxbridge | Unknown toxicity, PCB, metals, nutrients, organic enrichment/low DO, flow alteration, fecal coliform bacteria, suspended solids, turbidity |
| | Rice City Pond, Uxbridge to the Water Quality Monitor, Millville | Unknown toxicity, PCB, metals, nutrients, pH, flow alteration, suspended solids, turbidity |
| | From the Water Quality Monitor, Millville to the Rhode Island Border | PCB, nutrients, pH, flow alteration, fecal coliform bacteria, suspended solids, turbidity |
| Unnamed tributary (also known as "Mill Brook") | Outlet Indian Lake to confluence with the Blackstone River, Worcester (flows through an underground conduit) | PCB, metals, unionized ammonia, nutrients, organic enrichment/low DO, fecal coliform bacteria, suspended solids, turbidity |
| Peters River | Outlet Curtis Pond, Bellingham to Rhode Island state line | Metals, fecal coliform bacteria |
| Mill River | Outlet North Pond, Milford/Upton to confluence with Blackstone River, Woonsocket, Rhode Island | PCB, metals |
| West River | Outlet Silver Lake, Upton to Upton WWTP | pH, organic enrichment/low DO, fecal coliform bacteria |
| | Upton WWTP to confluence with Blackstone River, Uxbridge | Metals, nutrients, pH, organic enrichment/low DO, salinity/TDS/chlorides |
| Mumford River | Douglas WWTP to confluence with Blackstone River, Uxbridge | Metals, pH, organic enrichment/low D.O., fecal coliform bacteria |
| Middle River | Curtis Pond to American Steel Dam, Worcester | Unknown toxicity, metals, nutrients, pH, fecal coliform bacteria, turbidity |
| Kettle Brook | Waite Pond, Leicester to Curtis Pond, Worcester | Nutrients, fecal coliform bacteria |

*needs confirmation (additional data collection is necessary to confirm the presence of impairment)

Table 3. Continued. Waterbodies in the Blackstone River Basin included on the 1998 303(d) list.

| 1998 303(d) Listed Waterbody | | Cause of Impairment |
|---|---|---|
| Tatnuck Brook | Outlet Holden Reservoir #2, Holden to confluence with Beaver Brook, Worcester | Turbidity |
| Aldrich Pond | Sutton | Noxious aquatic plants |
| Auburn Pond | Auburn | Noxious aquatic plants |
| Brierly Pond | Millbury | Noxious aquatic plants |
| Burncoat Park Pond | Worcester | Noxious aquatic plants, turbidity |
| Chase Pond | Douglas | Noxious aquatic plants |
| Cider Millpond | Grafton | Noxious aquatic plants |
| City Farm Pond | Shrewsbury | Siltation, noxious aquatic plants |
| Clark Reservoir | Sutton | Noxious aquatic plants |
| Crane Pond | Blackstone | Noxious aquatic plants |
| Crystal Lake | Douglas | Noxious aquatic plants |
| Curtis Pond (North Basin) | Worcester | Noxious aquatic plants |
| Curtis Pond (S. Basin) | Worcester | Siltation, Noxious aquatic plants |
| Dark Brook Pond | Sutton | Noxious aquatic plants |
| Dark Brook Reservoir | Auburn | Noxious aquatic plants |
| Dorothy Pond | Millbury | Turbidity |
| Dudley Pond | Douglas | Noxious aquatic plants |
| Eddy Pond | Auburn | Noxious aquatic plants |
| Fish Pond | Northbridge | Noxious aquatic plants |
| Fiske Millpond | Upton/Milford | Noxious aquatic plants |
| Flint Pond | Shrewsbury/Grafton/Worcester | Turbidity |
| Gilboa Pond | Douglas | Noxious aquatic plants |
| Green Hill Pond | Worcester | Turbidity |
| Harris Pond | Blackstone | Noxious aquatic plants |
| Hathaway Pond | Millbury/Sutton | Noxious aquatic plants |
| Hayes Pond | Grafton | Noxious aquatic plants |
| Hopedale Pond | Hopedale | Noxious aquatic plants |
| Hovey Pond | Grafton | Noxious aquatic plants |
| Howe Pond | Millbury | Noxious aquatic plants |
| Howe Reservoir (E Basin) | Millbury | Flow alteration, noxious aquatic plants |
| Howe Reservoir (West) | Millbury | Noxious aquatic plants |
| Indian Lake | Worcester | Organic enrichment/ low DO, noxious aquatic plants |
| Ironstone Reservoir | Uxbridge | Noxious aquatic plants |
| Jenks Reservoir | Bellingham | Noxious aquatic plants |
| Joes Rock Pond | Wrentham | Noxious aquatic plants |
| Jordan Pond | Shrewsbury | Turbidity |
| Lee Reservoir | Uxbridge | Noxious aquatic plants |
| Leesville Pond | Auburn/Worcester | Nutrients, organic enrichment/ low DO |
| Manchaug Pond | Douglas/Sutton | Organic enrichment/ low DO, noxious aquatic plants |
| Marble Pond | Sutton | Noxious aquatic plants |
| Martin Street Pond | Douglas | Noxious aquatic plants |
| Merrill Pond No. 3 | Sutton | Noxious aquatic plants |
| Merrill Pond No. 4 | Sutton | Noxious aquatic plants |
| Milford Street Pond | Hopedale/Milford | Noxious aquatic plants |
| Mill Pond | Upton | Noxious aquatic plants |
| Mill Pond | Shrewsbury | Turbidity |
| Miscoe Lake | Wrentham/Cumberland, RI | Noxious aquatic plants |
| Newton Pond | Shrewsbury/Boylston | Noxious aquatic plants |
| Number 1 Pond | Sutton | Noxious aquatic plants, turbidity |
| Number 2 Pond | Sutton | Noxious aquatic plants |
| Peabody Pond | Uxbridge | Noxious aquatic plants |
| Pondville Pond | Auburn | Noxious aquatic plants |
| Pout Pond | Boylston | Noxious aquatic plants |
| Pratt Pond | Upton | Noxious aquatic plants |
| Pratts Pond | Grafton | Noxious aquatic plants |
| Lake Quinsigamond | Shrewsbury/Worcester | Noxious aquatic plants |
| Rice City Pond | Uxbridge | PCB, turbidity |
| Riley Pond | Northbridge | Turbidity |
| Lake Ripple | Grafton | Noxious aquatic plants |
| Riverdale Impoundment | Northbridge | PCB, turbidity |
| Rivulet Pond | Uxbridge | Noxious aquatic plants |
| Salisbury Pond | Worcester | Noxious aquatic plants, turbidity |
| Schoolhouse Pond | Sutton | Noxious aquatic plants |
| Silver Hill Pond | Milford | Noxious aquatic plants |

*needs confirmation (additional data collection is necessary to confirm the presence of impairment)

Table 3. Continued. Waterbodies in the Blackstone River Basin included on the 1998 303(d) list.

| 1998 303(d) Listed Waterbody | | Cause of Impairment |
|---|---|---|
| Silver Lake | Bellingham | Noxious aquatic plants |
| Silver Lake | Grafton | Noxious aquatic plants |
| Slaughterhouse Pond | Millbury/Sutton | Noxious aquatic plants |
| Smiths Pond | Leicester | Turbidity |
| Southwick Pond | Leicester/Paxton | Noxious aquatic plants |
| Spindleville Pond | Hopedale | PCB, noxious aquatic plants |
| Stoneville Pond | Auburn | Noxious aquatic plants |
| Sutton Falls | Sutton | Turbidity |
| Swans Pond | Sutton | Noxious aquatic plants |
| Taft Pond | Upton | Noxious aquatic plants |
| Town Farm Pond | Sutton | Noxious aquatic plants |
| Tuckers Pond | Sutton | Noxious aquatic plants |
| Welsh Pond | Sutton | Noxious aquatic plants |
| West River Pond | Uxbridge | Noxious aquatic plants |
| Whitins Pond | Northbridge/Sutton | Noxious aquatic plants |
| Lake Wildwood | Upton/Grafton | Noxious aquatic plants |
| Windle Pond | Grafton/Shrewsbury | Noxious aquatic plants |
| Woodbury Pond | Sutton | Noxious aquatic plants |
| Woolshop Pond | Millbury | Noxious aquatic plants, turbidity |
| Sewall Pond | Boylston | Noxious aquatic plants |
| Meadow Pond | Northbridge/Sutton | Noxious aquatic plants |
| Doctors Pond | Uxbridge | Noxious aquatic plants |
| Brooklawn Parkway Pond | Shrewsbury | Noxious aquatic plants |
| Shirley Street Pond | Shrewsbury | Noxious aquatic plants |
| Arcade Pond* | Northbridge | Noxious aquatic plants |

*needs confirmation (additional data collection is necessary to confirm the presence of impairment)

## SOURCES OF INFORMATION

Multiple local, state and federal agencies provided information used in the water quality assessment of the Blackstone River Basin. Within the Department of Environmental Protection (DEP) information was obtained from three programmatic bureaus: Bureau of Resource Protection (BRP, see below), Bureau of Waste Prevention (industrial wastewater discharge information) and the Bureau of Waste Site Cleanup (hazardous waste site cleanup information). Specifically, DEP BRP Division of Watershed Management (DWM) Watershed Planning Program provided water quality, habitat assessment, biological data, and lake synoptic survey data. The DEP Central Regional Office, Blackstone River Watershed Team and the DWM Watershed Permitting Program (Water Management Act, and National Pollutant Discharge Elimination System) provided water withdrawal and wastewater discharge permit information. [Note: The BRP DWM Drinking Water Program evaluates the status of the *Drinking Water Use* and this information is therefore not provided in this assessment report.]

Projects funded through various DEP grant and loan programs also provide valuable information that may be used in the water quality assessment report. A summary of these projects for the Blackstone River Basin is provided in Appendix E.

Other state agencies contributing information to this report include: the Massachusetts Department of Public Health (DPH), the Department of Fisheries, Wildlife, and Environmental Law Enforcement (DFWELE) Division of Fisheries and Wildlife and Riverways programs, the Department of Environmental Management (DEM), and the UMass Extension Service. Contributing federal agencies include EPA, United States Geological Survey (USGS), Federal Energy Regulatory Commission, and the United States Army Corps of Engineers (ACOE).

The ACOE New England Division (NAE) owns and operates numerous flood control projects throughout the nation, including the West Hill Dam project on the West River (Upton, Northbridge, and Uxbridge). The West Hill Dam project is a dry-bed reservoir, and does not maintain a conservation pool behind the dam. It operates run-of-river except during flooding events. The ACOE owns 614 acres within the project area, and has easements on an additional 838 acres. Most of the land use in the 27.9 square mile drainage area consists of rural, forested and low density residential land; however, this area is under

intense development pressure, with numerous developments under construction both up- and downstream of the ACOE property.

The goals of the ACOE reservoir water quality control management program, established in 1982, protecting public health and safety, meeting State water quality standards, maintaining the water quality necessary to meet the individual project goals, and identifying the impacts of the projects on water quality (Barker, 1998). Activities conducted under the Reservoir Water Quality Operation and Maintenance Program during fiscal year 1999 (October 1, 1998 through September 30, 1998) include potable water and bathing beach water quality monitoring, baseline monitoring of Class I projects with conservation pools, and the continuation of a study on the relationship between rainfall and elevated bacteria counts at project beaches (among other projects). Beaches are monitored biweekly from May through Labor Day. The assessment of the data collected in these programs are presented in annual reports; the reports utilized in this assessment are for Fiscal Years 1997- 1999 (Barker, 1999, 1998, 1999a). The West Hill Dam project is considered to be a Class I project i.e., it exhibits consistently high water quality, based on previous NAE water quality reports, state water quality reports, changes between inflow and discharge water quality, frequency of violation of water quality criteria, and the presence/absence of a conservation pool (Barker, 2000). Data collected at the sampling station at West Hill Dam from FY 1997-2000 showed that water quality was within the good to excellent range, indicating that the state water quality standards were met or exceeded, and that the water quality met the needs of the project (i.e., recreation, fish and wildlife habitat).

In addition to state and federal agencies, regional, local and citizen monitoring groups provided valuable data/information for the watershed management process which may be used to indicate areas of degraded water quality, as well as causes and sources of contamination. The Blackstone River Watershed Association (BRWA) is a nonprofit organization dedicated to restoring and enhancing the environmental quality of the waters and adjacent lands of the Blackstone River and its tributaries (BRWA 18 April 2001). The BRWA's objectives are:

- to restore the waters of the Blackstone and its tributaries to their highest possible quality and protect their shores and floodplains from inappropriate uses;
- to enhance the natural integrity of and protect public access to the river, canal, and tributaries for canoeing, fishing, and other recreational pursuits;
- to preserve the rural and forested character of the Blackstone Valley and protect lands with ecological, recreational, and/or scenic value.

From 1996 through 2000, shoreline surveys were conducted by volunteers in many headwater streams of the Blackstone River in Shrewsbury and Worcester (Coffin 24 January 2001). These surveys were carried out by the BRWA, the Blackstone Headwaters Coalition, the Tatnuck Brook Stream Team, Coes and Patches Watershed Association, and the Flint Pond Stream Team. Locations surveyed included Kinneywood Brook, Cooks Pond, Peter's Brook, Boynton/Cascades Brook, West Tatnuck Brook, Patch Reservoir, Country Club Tributary, Fowler Brook, Worcester State College tributary, Williamsburg Ave tributary, Coes Reservoir, Beaver Brook, Tatnuck Brook, Middle River, Poor Farm Brook, Flint Pond, and the Mumford River. Teams on shore and in boats noted conditions in the water bodies and along the banks, and recorded land uses, erosion, surface pipes, siltation/sedimentation, trash, odors, sheens, foams, aquatic vegetation, color, solid waste, and recreational resources.

Site-specific evaluations of other water quality issues in the Blackstone River Basin related to either wastewater discharges and/or water withdrawals were conducted either through field investigations (where resources could be allocated) or through the review of discharge monitoring reports (DMRs) and annual water withdrawal reports submitted by the permittees. Water withdrawal and wastewater discharge permit information was provided by the DEP Central Regional Office Blackstone River Watershed Team and the DWM Watershed Permitting Program (Water Management Act - WMA and National Pollutant Discharge Elimination System –NPDES).

The Blackstone River Basin has facilities that discharge to the mainstem of the river and to several of its tributaries (Appendix D, Table D1). The following types of NPDES discharges occur in the Blackstone River Basin (Hogan 2000):

- *Municipal wastewater treatment plants (WWTPs):* these facilities treat wastewater from domestic and industrial sources within the WWTP service area. Five discharge to the mainstem Blackstone River in

Massachusetts - Upper Blackstone Water Pollution Abatement District {UBWPAD} (the largest point source discharge in the watershed); Millbury WWTP (scheduled to be connected to UBWPAD); Grafton WWTP; Northbridge WWTP (actually discharges to unnamed stream near the mainstem); Uxbridge WWTP. Three facilities discharge to tributaries of the Blackstone River; Douglas WWTP (Mumford River), Upton WWTP (West River) and the Hopedale WWTP (Mill River). These discharges range in size from the Douglas WWTP, which has a current capacity of 0.18 MGD and treats only municipal, sanitary wastewater to the regional UBWPAD facility with a treatment capacity of 56 MGD. The UBWPAD discharges into the upper reaches of the mainstem, just downstream of the confluences of the smaller tributaries forming the headwaters of the river. These headwater tributaries drain the seven hills of the City of Worcester and parts of surrounding towns, presenting a situation of urban headwaters and a large NPDES discharger with low dilution. Specifically, the UBWPAD accounts for approximately 90% of the wastewater discharged to the Blackstone River in Massachusetts. The river is therefore effluent-dominated for a number of river miles in the upper and middle reaches, especially during extended periods low-flows.

- *Combined Sewer Overflows* (Brander 2001): The city of Worcester has completed considerable work with regard to CSO abatement including the construction of a CSO treatment facility and ongoing sewer separation. At this time, there is a single CSO discharge point, and all CSO discharges receive screening and disinfection with some solids removal in detention tanks prior to discharge. As a result of an Administrative Order issued by EPA on 19 September 2000, the City of Worcester will continue to move forward with a two-phased Long-term CSO Control Plan. Phase one will involve characterizing the combined sewer system, establishing baseline conditions for CSO and non-CSO pollutant loads, and developing costs for a range of CSO control alternatives (approximately one year). Phase two will focus on the development of a final Long-term CSO Control Plan (approximately one year). If non-CSO loads are determined to be a predominant contributor to violations of SWQS, then the final strategy for CSO abatement will likely be meshed with storm water management strategies in order to maximize the cost-effectiveness of the overall program.

  The treated CSO discharges flow to Mill Brook and the Blackstone River. These segments are both presently designated Class B. A CSO-impacted segment can be reclassified to B(CSO), B(partial), C, or a CSO Variance can be issued only where a CSO facilities plan demonstrates that elimination of CSOs is not feasible. In those instances, the highest feasible level of CSO control must be implemented and the receiving water may be reclassified accordingly. The technical and cost information included in the CSO Facilities Plan forms the basis of these determinations and must support a Use Attainability Analysis where a downgrade to B(CSO), B(partial), or C is being considered. A CSO Variance may be issued to allow continued discharge of CSOs while additional data and information are developed to make a final determination on the appropriate water quality standard. As the City of Worcester has not completed the planning process, a final determination on the level of CSO control to be required and the associated water quality standard have not yet been made. Until such time, the receiving waters will continue to be designated Class B (Brander 2001).

- *Industrial WWTPs and non-process discharges:* the majority of industrial process wastewaters are treated at the municipal WWTPs (particularly the UBWPAD) under conditions of their industrial pre-treatment program (IPP). The IPP is controlled by the municipality and is a condition of the municipal WWTP NPDES permit. There are three major industrial discharges (New England Plating; Guilford of Maine; Wyman-Gordon, Grafton) in the Blackstone River Basin and three minor discharges (Lewcott Corp., Norton Co., and Coz Chemical). [Note: There are also several industries which have NPDES permits for the discharge of non-contact cooling water and storm water; some of these discharges are authorized and controlled under individual permits while others are regulated under general permits issued to the facilities by USEPA.]

Two FERC licensed hydroelectric power plants effect the Blackstone River in Massachusetts:

- Riverdale Mills, Northbridge (FERC Project # 9100)
- Synergics Hydropower in the village of Waterford (FERC Project # 3023), just over the Massachusetts state line in Rhode Island

NPDES Toxicity Testing Discharge Monitoring Reports (DMRs):
All eight municipal wastewater treatment plants in the Blackstone River Basin submit toxicity testing reports to EPA and DEP as required by their NPDES permits. Data from these toxicity reports are maintained by DWM in a database entitled "Toxicity Testing Data - TOXTD". Information from the reports includes: survival of test organisms exposed to ambient river water (used as dilution water), physicochemical analysis (e.g., hardness, alkalinity, pH, total suspended solids) of the dilution water, and the whole effluent toxicity test results. Data from January 1996 to April 2000 were reviewed and summarized (ranges) for use in the assessment of current water quality conditions in the Blackstone River Basin. These include:

- Upper Blackstone WPAD MA0102369
- Millbury WWTP(MA0100650)
- Uxbridge WWTF (MA0102440)
- Grafton WWTP (MA0101311)
- Northbridge WWTF (MA0100722)
- Douglas WWTF(MA0101095)
- West Upton WWTF (MA0100196)
- Hopedale WWTF (MA0102202)
- Worcester CSO Treatment Facility (MA0102997
- New England Plating Company, Worcester (MA0005088)
- Wyman-Gordon (MA0004341)
- Coz Plastics, Inc. (MA0032549)
- Guilford of Maine, Inc. East Douglas Division (MA0001538)
- Riverdale Mills (MAG250279)

A list of registered and permitted Water Management Act (WMA) withdrawals (both public water suppliers and other industrial users) is provided in Appendix D, Table D2 (LeVangie 2000).

## TOTAL MAXIMUM DAILY LOADS (TMDL)

As part of the Federal Clean Water Act, states are required to develop TMDLs for lakes, rivers and coastal waters not meeting the states surface water quality standards as indicated by the states 303d list of impaired waters. A TMDL is the greatest amount of a pollutant that a waterbody can accept and still meet standards. Further information on the 303d list and the TMDL program are available on the DEP website at: http://www.dep.state.ma.us/dep/brp/wm/wmpubs.htm.

### RIVERS

MADEP and USEPA are drafting a Low Flow Seasonal TMDL for nutrients and organic enrichment/low dissolved oxygen for the mainstem of the Blackstone River (segments MA51-03 through MA51-06). Although the mainstem of the river is on the 1998 303(d) list for multiple causes, the first Blackstone River TMDL focused on organic enrichment (BOD)/low dissolved oxygen, and excessive nutrients (phosphorus) to coincide with the on-going work on the NPDES municipal permits. The TMDL is based upon the extensive field and modeling work completed under the interstate/interagency Blackstone River Initiative, the five-year cycle of the Watershed Approach, the DEP/CERO strategic monitoring program, and the wasteload allocation work completed in 1998. A load-response relationship was developed between the municipal facility discharges and the dissolved oxygen levels in the river. Control measures target new storm water management through permitting, education, and grants; development of BMPs; CSO permit reissuance; concurrent issuance of TMDLs for selected lakes in the watershed; and changes to the NPDES municipal discharge effluent limits. The proposed limits are expected to improve water quality instream through meeting standards for target constituents. Once the draft TMDL is completed, the report will be made available for public comment (MA DEP 2000a).

**LAKES**

There are eighty-eight lakes in the Blackstone basin on the 1998 303(d) list for which the most common cause of impairment is noxious aquatic plants (Table 3). A single draft TMDL for Total Phosphorus is being developed for 16 of these lakes located in the northern section of the basin, which will include (MA DEP 2000c):

> **Auburn Pond** (MA51004), Auburn; **Brierly Pond** (MA51010), Millbury; **Curtis Pond North** (MA51032), Worcester; **Curtis Pond South** (MA51033), Worcester; **Dorothy Pond** (MA51039), Millbury; **Eddy Pond** (MA51043), Auburn; **Green Hill Pond** (MA51056), Worcester; **Howe Reservoir** (MA51071), Millbury; **Jordan Pond** (MA51078), Shrewsbury; **Mill Pond** (MA51105), Shrewsbury; **Newton Pond** (MA51110), Shrewsbury; **Pondville Pond** (MA51120), Auburn; **Smiths Pond** (MA51156), Leicester; **Southwick Pond** (MA51157), Leicester, **Stoneville Pond** (MA51160), Auburn; **Shirley Street Pond** (MA51196), Shrewsbury.

This draft TMDL will be available for public comment in 2001, and the final revised version is scheduled to be submitted to EPA by the end of 2001 (Mattson 2001).

In addition, draft phosphorus TMDLs based on previous diagnostic/feasibility studies are being developed for Lake Quinsigamond/Flint Pond, Indian Lake, Salisbury Pond and Leesville Pond. These draft phosphorus TMDLs will also be announced for public comment in 2001.

Two additional impoundments (Rice City Pond and Riverdale Impoundment) on the Blackstone River will be included in a draft TMDL for phosphorus for the Blackstone River as described above (MA DEP 2000a).

TMDLs for the remaining Blackstone River Basin lakes are scheduled to be developed on the Five-year watershed cycle in 2004 and 2009.

## OBJECTIVES

This report summarizes information generated in the Blackstone River Basin through *Year 1* (information gathering in 1997) and *Year 2* (environmental monitoring in 1998) activities established in the "Five-Year Cycle" of the Watershed Initiative. Data collected by DWM in 1998, in accordance with the preliminary Quality Assurance Project Plan (QAPP) (Hartman and Fiorentino 1999), are provided in Appendices A, B, and C (QA/QC, data tables, and the technical memorandum - Blackstone River Watershed 1998 Biological Assessment). Together with other sources of information (identified in each segment assessment), the status of water quality conditions of lakes and rivers in the Blackstone River Basin was assessed in accordance with EPA's and DEP's use assessment methods. Not all waters in the Blackstone River Basin are included in the DEP/EPA Water Body System (WBS) database or this report.

The objectives of this water quality assessment report are to:

1. Evaluate whether or not surface waters in the Blackstone River Basin, defined as segments in the WBS database, currently support their designated uses (i.e., meet surface water quality standards),
2. identify water withdrawals (habitat quality/water quantity) and/or major point (wastewater discharges) and nonpoint (land-use practices, storm water discharges, etc.) sources of pollution that may impair water quality conditions,
3. identify the presence or absence of any non-native macrophytes in lakes,
4. identify waters (or segments) of concern that require additional data to fully assess water quality conditions,
5. recommend additional monitoring needs and/or remediation actions in order to better determine the level of impairment or to improve/restore water quality, and
6. provide information to the Blackstone River Watershed Team for use in its annual and 5-year watershed action plans.

## REPORT FORMAT

### *RIVERS*

The rivers assessed in the Blackstone River Basin are presented in the *River Segment Assessments* section of this report (Figure 5). The order of river segments follows the Massachusetts Stream Classification Program (Halliwell *et al.* 1982) hierarchy. River segments are organized hydrologically (from most upstream to downstream) and tributary segments follow after the river segment into which they discharge. Each river segment assessment is formatted as follows:

**SEGMENT IDENTIFICATION**

Name, water body identification number (WBID), location, length, classification.

Sources of information: coding system (waterbody identification number e.g., MA51-01) used by DEP to reference the stream segment in databases such as 305(b) and 303(d), the Massachusetts SWQS (MA DEP 1996), and other descriptive information.

**SEGMENT DESCRIPTION**

Major land-use estimates (the top three uses for the subwatershed excluding "open water") and other descriptive information.

Sources of information: descriptive information from USGS topographical maps, base geographic data from MassGIS, land use statistics from a GIS analysis using the MassGIS land use coverage developed at a scale of 1:25,000 and based on aerial photographs taken in 1985 and 1990 (EOEA 1999a).

**SEGMENT LOCATOR MAP**

Subbasin map, major river location, segment origin and termination points, and segment drainage area (gray shaded).

Sources of information: MassGIS (EOEA 1999b) data layers (stream segments, and quadrangle maps).

**WATER WITHDRAWALS AND WASTEWATER DISCHARGE PERMIT INFORMATION**

Water withdrawal, NPDES wastewater discharge (when provided)

Sources of information: WMA Database Printout (LeVangie 2000); open permit files located in Worcester DEP Office (MA DEP 2000e and f).

**USE ASSESSMENT**

Aquatic Life, Fish Consumption, Drinking Water (where applicable – see note below), Primary Contact, Secondary Contact, and Aesthetics.

Sources of information include: DWM 1998 Survey data (Appendix B and Appendix C); USGS streamflow and water quality data (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000); the Blackstone River Initiative Reports (Wright *et al.* 1996); the US ACOE Blackstone River Watershed Reconnaissance Investigation (US ACOE 1997), Rice City Pond 319 Project (Snook 1996); DEP DWM Toxicity Testing Database "TOXTD"; BRWA and Stream Team reports (Coffin 24 January 2001). The MA DPH Freshwater Fish Consumption Advisory List (MA DPH 1999) was used to assess the *Fish Consumption Use*. Where other sources of information were used to assess designated uses, citations are included.

[Note: Although the *Drinking Water Use* itself was not assessed in this water quality assessment report, the Class A waters were identified.]

**SUMMARY**

Use summary table (uses, status, causes and sources of impairment).

**RECOMMENDATIONS**

Additional monitoring and implementation needs.

### *LAKES*

The assessed lakes (Figure 6), identified with their Water Body System Identification (WBID) code numbers, are listed alphabetically in the *Lake Assessments* section of this report (Tables 5 and 6). The status of the individual uses is presented collectively for all of the lakes in the basin. The location, acreage, and trophic status, as well as the use assessments and causes of impairment are then summarized for each individual lake (listed alphabetically).

# BLACKSTONE RIVER BASIN – RIVER SEGMENT ASSESSMENTS

Fifty-six percent of the 204 river miles in the Blackstone River Basin are included in this report (Figure 5).

The following segments in the Blackstone River Basin are included in this report:



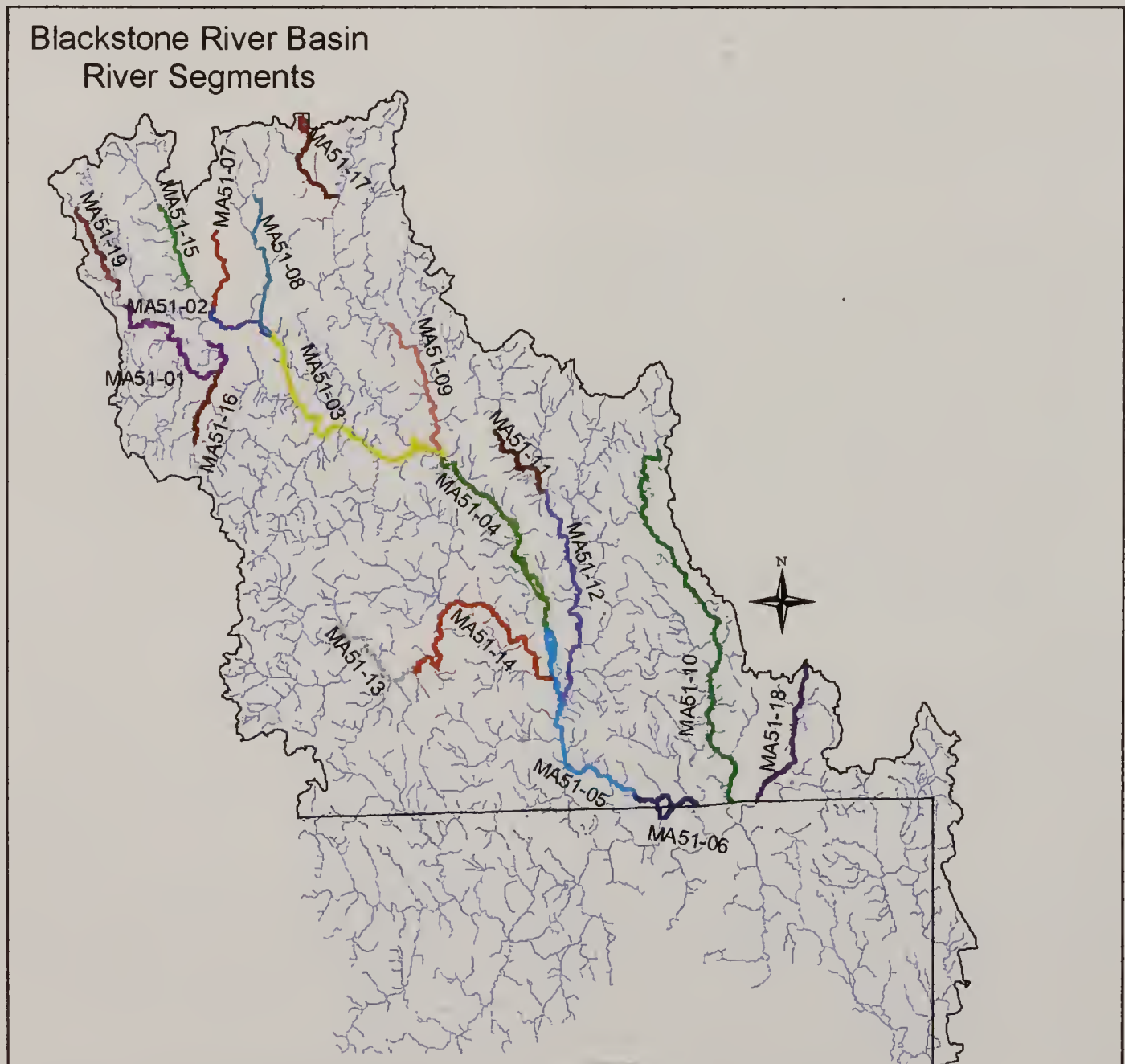



Figure 5. River segment locations in the Blackstone River Basin.

## REPORT FORMAT

### *RIVERS*

The rivers assessed in the Blackstone River Basin are presented in the *River Segment Assessments* section of this report (Figure 5). The order of river segments follows the Massachusetts Stream Classification Program (Halliwell *et al.* 1982) hierarchy. River segments are organized hydrologically (from most upstream to downstream) and tributary segments follow after the river segment into which they discharge. Each river segment assessment is formatted as follows:

**SEGMENT IDENTIFICATION**

Name, water body identification number (WBID), location, length, classification.

Sources of information: coding system (waterbody identification number e.g., MA51-01) used by DEP to reference the stream segment in databases such as 305(b) and 303(d), the Massachusetts SWQS (MA DEP 1996), and other descriptive information.

**SEGMENT DESCRIPTION**

Major land-use estimates (the top three uses for the subwatershed excluding "open water") and other descriptive information.

Sources of information: descriptive information from USGS topographical maps, base geographic data from MassGIS, land use statistics from a GIS analysis using the MassGIS land use coverage developed at a scale of 1:25,000 and based on aerial photographs taken in 1985 and 1990 (EOEA 1999a).

**SEGMENT LOCATOR MAP**

Subbasin map, major river location, segment origin and termination points, and segment drainage area (gray shaded).

Sources of information: MassGIS (EOEA 1999b) data layers (stream segments, and quadrangle maps).

**WATER WITHDRAWALS AND WASTEWATER DISCHARGE PERMIT INFORMATION**

Water withdrawal, NPDES wastewater discharge (when provided)

Sources of information: WMA Database Printout (LeVangie 2000); open permit files located in Worcester DEP Office (MA DEP 2000e and f).

**USE ASSESSMENT**

Aquatic Life, Fish Consumption, Drinking Water (where applicable – see note below), Primary Contact, Secondary Contact, and Aesthetics.

Sources of information include: DWM 1998 Survey data (Appendix B and Appendix C); USGS streamflow and water quality data (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000); the Blackstone River Initiative Reports (Wright *et al.* 1996); the US ACOE Blackstone River Watershed Reconnaissance Investigation (US ACOE 1997), Rice City Pond 319 Project (Snook 1996); DEP DWM Toxicity Testing Database "TOXTD"; BRWA and Stream Team reports (Coffin 24 January 2001). The MA DPH Freshwater Fish Consumption Advisory List (MA DPH 1999) was used to assess the *Fish Consumption Use*. Where other sources of information were used to assess designated uses, citations are included.

[Note: Although the *Drinking Water Use* itself was not assessed in this water quality assessment report, the Class A waters were identified.]

**SUMMARY**

Use summary table (uses, status, causes and sources of impairment).

**RECOMMENDATIONS**

Additional monitoring and implementation needs.

### *LAKES*

The assessed lakes (Figure 6), identified with their Water Body System Identification (WBID) code numbers, are listed alphabetically in the *Lake Assessments* section of this report (Tables 5 and 6). The status of the individual uses is presented collectively for all of the lakes in the basin. The location, acreage, and trophic status, as well as the use assessments and causes of impairment are then summarized for each individual lake (listed alphabetically).

## USE ASSESSMENT

### *AQUATIC LIFE*

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey of Kettle Brook, downstream from Earle St., Leicester KB10 (Appendix C). This station was the regional reference station and exhibited rich species diversity with a well-balanced community. Instream vegetation was minimal and consisted of isolated areas of filamentous algae (Appendix C, Table A7).

Chemistry – water

DWM physico-chemical water quality sampling (Station KB10) was conducted in July 1998 downstream from Earle St., Leicester (co-located with the DWM benthic macroinvertebrate sampling location) (Appendix B, Tables B5 and B6). The Hydrolab® and nutrient data did not indicate any water quality problems.

The benthic macroinvertebrate data indicated excellent water and habitat quality and therefore the *Aquatic Life Use* is assessed as support.

### *PRIMARY CONTACT AND SECONDARY CONTACT RECREATION*

DWM fecal coliform sampling (Station KB10) was conducted in July 1998 downstream from Earle St., Leicester (co-located with the DWM benthic macroinvertebrate sampling location) (Appendix B, Table B7). The fecal coliform bacteria count was <20 cfu/100mLs.

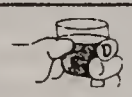
Too little fecal coliform bacteria data were available to assess either the *Primary* or *Secondary Contact Recreational* uses. It should be noted however, that the Worcester DPW, in protection of this drinking water supply, prohibits stream and shoreline activities in this area (Lemerise 30 April 2001)

### *AESTHETICS*

DWM conducted a habitat assessment (1998) on this segment of Kettle Brook as part of the benthic macroinvertebrate survey (Appendix C). Suspended solids and turbidity data were very low and no objectionable conditions were noted.

Based on the overall high aesthetic conditions, the *Aesthetics Use* is assessed as support.

Kettle Brook (MA51-19) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | SUPPORT | | | | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Drinking Water |  | The DEP Drinking Water Program maintains current drinking water supply data. | | | | |
| Primary Contact |  | NOT ASSESSED | | | | |
| Secondary Contact |  | NOT ASSESSED | | | | |
| Aesthetics |  | SUPPORT | | | | |

**RECOMMENDATIONS KETTLE BROOK (MA51-19)**

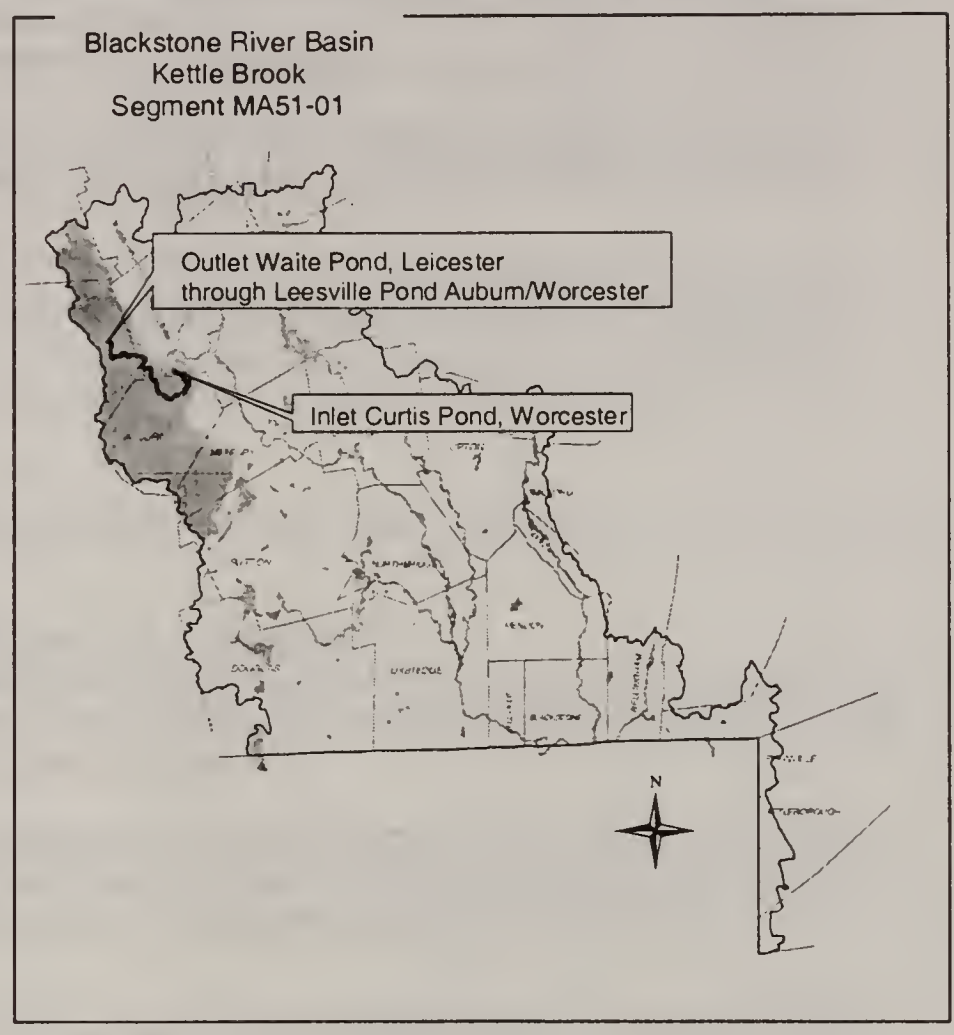
- Evaluate reservoir operations (Kettle Brook reservoirs - Worcester DPW WMA registration # 21234805) to maintain minimum and, to the extent possible, natural flow regimes in Kettle Brook. Determine potential impacts of withdrawals on streamflow/habitat.

- Until the WMA appeal process has been resolved for Worcester DPW's Blackstone River Basin permit request, continue to monitor their withdrawal volumes.

- When the DEP Drinking Water Program SWAP evaluations are completed, review, develop and implement recommendations to protect the Kettle Brook drinking water supplies.

## KETTLE BROOK (SEGMENT MA51-01)

Location: Outlet Waite Pond, Leicester through Leesville Pond Auburn/Worcester to inlet Curtis Pond, Worcester.
Segment Length: 8.0 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 54% |
| Residential | 19% |
| Agriculture | 7% |

The use assessments of Howe Reservoir (east basin), Hayes Pond, and Leesville Pond are provided in the Lakes Assessment section of this report (Tables 5 and 6).

In July 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in lower Kettle Brook. Four species of fish including, in order of dominance, white sucker, two individuals each of pumpkinseed and largemouth bass, and an individual yellow perch were collected (DFWELE undated).

***WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Auburn Water Department | 2017000 | 9P21201701 | 21201702 | 2017000-02G<br>2017000-04G<br>2017000-07G<br>2017000-05G<br>2017000-03G<br>2017000-01G<br>2017000-06G<br>2017000-08G | 1.75 MGD | 1.196 MGD |
| Leicester Water Supply District | 2151000 | | 21215101 | 2151000-01G<br>2151000-04G<br>2151000-03G<br>2151000-02G | 0.19 MGD | 0.18 MGD |
| Worcester DPW** | 2348000 | | 21234805 | Lynde Brook Reservoir | 14.22 MGD* | 15.33** |

* Indicates system-wide withdrawal within the Blackstone River Basin

**Worcester Department of Public Works (DPW) is registered (21234805) to withdraw a total of 14.22 MGD from seven surface water sources in the Blackstone River Basin (Holden Reservoirs #1 and 2; Lynde Brook Reservoir, and Kettle Brook Reservoirs #1-4). Worcester DPW is also registered (21134801) to withdraw a total of 9.85 MGD from four surface water sources (Quinapoxet, Kendall, and Pine Hill reservoirs and Asnebumskit Pond) in the Nashua River Basin, for a total system-wide registered withdrawal (both basins) of 24.07 MGD. Water from all sources (both Blackstone and Nashua river basins) is pumped to Holden Reservoir #1 where it is treated and distributed by Worcester's system. The interbasin transfer of water from the Nashua to the Blackstone River Basin is grandfathered since it existed prior to implementation of the Interbasin Transfer Act (IBT) (LeVangie 2000). Worcester DPW has applied for WMA permits in both the Blackstone and Nashua river basins. The city's Blackstone River Basin permit request was denied (due to exceedance of the firm safe yield) and, Worcester DPW has since appealed the denial which has yet to be settled. A decision has not yet been made on the Nashua River Basin permit application. Although not over their total system-wide (both basins) registered withdrawal (24.07 MGD), Worcester DPW has reported exceedances of their registration threshold volume from the Blackstone River Basin in 1998 and from the Nashua River Basin in 1999. In 1998, the Worcester DPW withdrew 15.33 MGD from their Blackstone River Basin sources but only 7.5 MGD from their Nashua River Basin sources for a total

withdrawal of 22.85 MGD. In 1999 however, they reported a withdrawal of 13.33 MGD from their Blackstone River Basin sources and 10.75 MGD from their Nashua River Basin sources for a total withdrawal of 24.08 MGD.

***NPDES WASTEWATER DISCHARGE SUMMARY:***

Nazareth Home For Boys (MA0025585) connected to Leicester POTW (a discharge in the French River Basin) at least one year ago.

Worcester Spinning and Finishing (MA0004171) has been closed.

Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Leesville Pond and Kettle Brook. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

General storm water permits have been issued to Creative Packaging, G.F. Wright Steel and Wire (direct discharges to Kettle Brook) as well as BFI Waste Systems, BFI Transcyclery, Kennedy Die Castings, and Champagne Auto Parts (discharges in the subwatershed) (Scarlet 2001).

**USE ASSESSMENT**

***AQUATIC LIFE***

Habitat and Flow

During the July DWM benthic macroinvertebrate survey, in the upstream portion of this segment (station KB09), habitat quality was limited as a result of low flow when compared to conditions observed in this portion of the brook in June (DWM field reconnaissance). Even lower flow conditions were observed in this portion of Kettle Brook at the time of DWM's fish population sampling in August 1998 (Appendix C). It should also be noted that the entire reach of Kettle Brook between Kettle Brook Reservoir No. 1 and Waite Pond (upstream of this segment) was dry during the survey.

Biology

In July 1998, DWM conducted two RBP III benthic macroinvertebrate surveys. Station KB09 was located downstream from Auburn St., Leicester at the upstream end of this segment of Kettle Brook. The RBP III analysis for this station indicated 67% comparability (slight impairment) to the regional reference station (KB10) (Appendix C). Fish population sampling at KB09 was conducted in August 1998. The survey yielded only four taxa, in order of dominance, white sucker (*Catostomus commersoni*), golden shiner (*Notemigonus crysoleucas*), bluegill (*Lepomis macrochirus*) and pumpkinseed (*L. gibbosus*). Low flow conditions, either naturally occurring or the result of upstream water use (e.g. reservoir operations, water withdrawals, etc.) may effect the biological communities in this reach of Kettle Brook (Appendix C).

Station KB02 was located downstream from Oxford St. below the outlet of Leesville Pond, Worcester near the end of this segment. The RBP III analysis for this station also indicated 67% comparability (slight impairment) to the regional reference station. The *Aquatic Life Use* for Leesville Pond (a hypereutrophic waterbody on the 1998 303(d) list because of nutrients and organic enrichment), is also impaired (see Lake Assessment section, Tables 5 and 6). Periphyton samples collected by DWM at KB02 had fairly low densities and were dominated by the filamentous green alga *Stigeoclonium tenue*. The presence of this filamentous alga is also indicative of organic enrichment (Appendix C).

Chemistry – water

DWM physico-chemical water quality sampling was conducted at two stations on this segment of Kettle Brook. Station KB09 (downstream from Auburn St., Leicester) was sampled in July 1998 and station KB02 (upstream from Oxford Street, Worcester) was sampled in June, July and August 1998. These stations were co-located with the DWM benthic macroinvertebrate sampling locations (Appendix B,

Tables B5 and B6). The limited data did not indicate any obvious water quality problems although hardness, alkalinity, chlorides, and turbidity were all higher at the downstream station.

Although the limited physico-chemical data indicated no obvious signs of water quality degradation, the biological communities (benthic macroinvertebrate, fish and periphyton) were slightly impaired and therefore the *Aquatic Life Use* is assessed as partial support. This impairment is likely the result of low flow conditions although downstream from the confluence with Dark Brook organic enrichment is also considered a cause of impairment.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

DWM fecal coliform bacteria sampling was conducted at two stations on this segment of Kettle Brook (Appendix B, Figure B1). KB09 (downstream from Auburn St., Leicester) was sampled in July 1998 and KB02 (upstream from Oxford Street, Worcester) was sampled in June, July and August 1998. At the upstream station the fecal coliform bacteria count was 380 cfu/100mLs while at the downstream station (KB02) samples were as high as 880 cfu/100mLs (Appendix B, Table B7). Two of the samples were above 400 cfu/100mLs during dry weather sampling conditions (Appendix B, Results - Survey Conditions).

Although two of the fecal coliform bacteria counts exceeded the guidance used to support the *Primary Contact Recreational Use* (>400 cfu/100mLs), the dataset was too limited to assess either of the recreational uses. The recreational uses are on "Alert Status" because of elevated levels of fecal coliform bacteria during dry weather conditions.

***AESTHETICS***

DWM conducted a habitat assessment (1998) on this segment of Kettle Brook at two stations (KB09 and KB02) as part of the benthic macroinvertebrate survey (Appendix C). Deposits of trash and debris were observed throughout both sampling reaches.

Based on the trash and debris in this segment of Kettle Brook, the *Aesthetics Use* is assessed as partial support.

Kettle Brook (MA51-01) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | PARTIAL SUPPORT | Unknown, Flow alteration, organic enrichment | | Unknown, hydromodification, urban runoff | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact* |  | NOT ASSESSED | | | | |
| Secondary Contact* |  | NOT ASSESSED | | | | |
| Aesthetics |  | PARTIAL SUPPORT | Trash/debris | | Urban runoff | |

* "Alert Status" issues identified.

**RECOMMENDATIONS KETTLE BROOK (MA51-01)**

- Conduct a stream cleanup near DWM's sampling station KB09 to remove broken glass, bricks, scrap metal, and other forms of urban debris. Actions should be taken to prevent further dumping of trash and debris at this site.

- Evaluate compliance of all water withdrawers with their WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- Until the WMA appeal process has been resolved for Worcester DPW's Blackstone River Basin permit request, continue to monitor their withdrawal volumes.

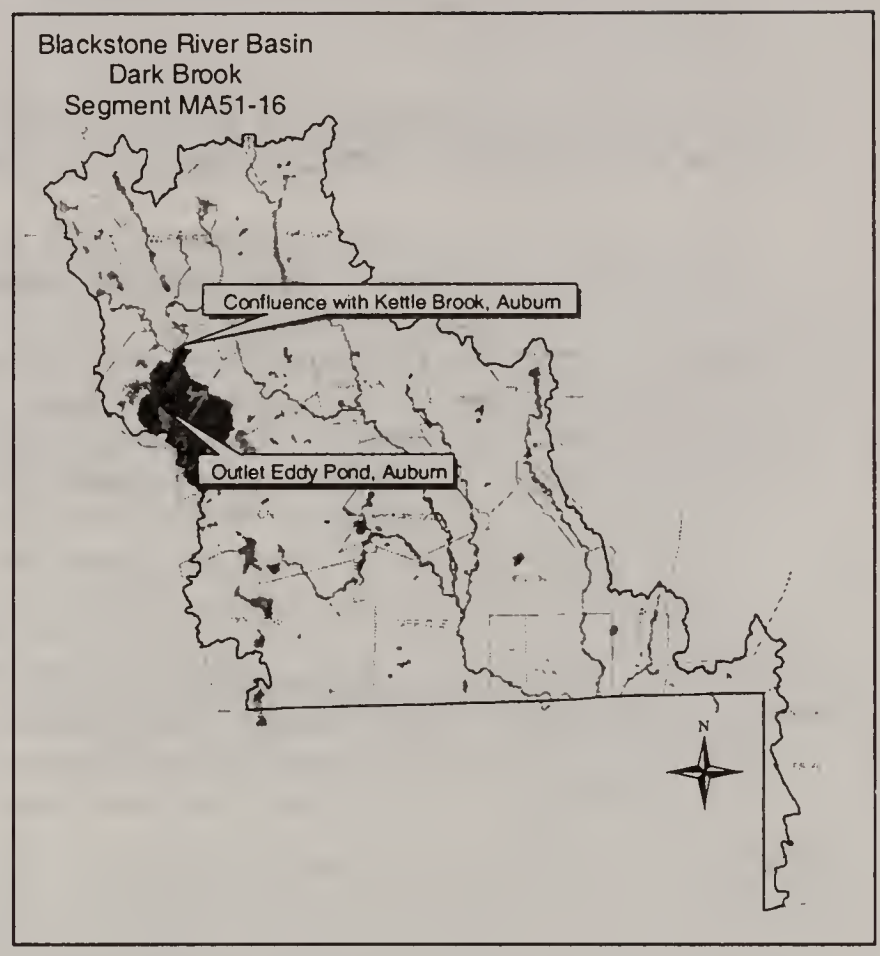
- Evaluate the flow regulation practices in the Kettle Brook Reservoir system to determine if the low flow conditions are naturally occurring or anthropogenic. Collect additional data to determine the frequency, duration, and spatial extent of the low flow conditions. Optimize withdrawal practices to maintain minimum flow and to the extent possible natural flow regimes in Kettle Brook.

- A draft phosphorus TMDL is being developed for Leesville Pond. Implement corrective actions identified in the final TMDL to reduce nutrient inputs to the pond and Kettle Brook.

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester's Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

## DARK BROOK (SEGMENT MA51-16)

Location: Outlet Eddy Pond, Auburn to confluence with Kettle Brook, Auburn.
Segment Length: 2.5 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 49% |
| Residential | 20% |
| Agriculture | 10% |

The use assessments of Eddy and Auburn ponds are provided in the Lakes Assessment section of this report (Tables 5 and 6).

***WMA WATER WITHDRAWAL AND NPDES WASTEWATER DISCHARGE SUMMARY:***
There are no known WMA regulated water withdrawals or surface water discharges to Dark Brook.

### USE ASSESSMENT

### *AQUATIC LIFE*

Biology

In July 1998, DWM conducted a RBP III benthic macroinvertebrate survey at one station on Dark Brook, downstream from Route 12, Auburn (station RB01) (Appendix C). The benthic community at station RB01 was 43% comparable to the regional reference station (KB10) indicating moderate impairment. Instream algae and aquatic vegetation were virtually absent in this sampling reach on Dark Brook (Appendix C, Table A7).

Fish population sampling conducted by DWM in August 1998 on Dark Brook (co-located at the benthic macroinvertebrate sampling location) yielded seven species of fish (Appendix C). The community was comprised, in order of dominance, of white sucker (*Catostomus commersoni),* tesselated darter (*Etheostoma olmstedi*), pumpkinseed (*L. gibbosus*), yellow bullhead (*Ameiurus natalis),* bluegill (*L. macrochirus),* largemouth bass (*Micropterus salmoides*) and chain pickerel (*Esox niger*).

Chemistry – water

DWM physico-chemical water quality sampling was also conducted at one station (RB01) on this segment of Dark Brook, downstream from Route 12, Auburn (Appendix B, Figure B1). Sampling was conducted on 8 July and 4 August 1998 (Appendix B, Tables B5 and B6). Both surveys were conducted during dry weather conditions and the data did not indicate any obvious water quality problems.

The benthic macroinvertebrate community was moderately impaired. Based on this data, the *Aquatic Life Use* is assessed as non-support. Although the causes and sources of this impairment are unknown, organic enrichment originating from eutrophic impoundments (Eddy and Auburn ponds) is suspected. Three of the seven fish species were identified as "pond species", further corroborating the influence of these upstream impoundments on water quality in Dark Brook.

### *PRIMARY CONTACT AND SECONDARY CONTACT RECREATION*

DWM fecal coliform bacteria sampling was conducted at one station (RB01) on Dark Brook, downstream from Route 12, Auburn. Sampling was conducted on 8 July and 4 August 1998 (Appendix B, Table B7). The fecal coliform bacteria data ranged from 82 to 440 cfu/100mLs with all samples collected during dry weather conditions.

Although one of the two fecal coliform bacteria counts slightly exceeded the guidance used to support the *Primary Contact Recreational Use* (≤400 cfu/100mLs), the dataset was too limited to assess either the *Primary* or *Secondary Contact Recreational* uses.

### *AESTHETICS*

DWM conducted a habitat assessment (1998) at station RB01 in Dark Brook as part of the benthic macroinvertebrate survey (Appendix C). No substantial objectionable conditions were identified. Instream suspended solids and turbidity results/measurements collected as part of the 1998 DWM survey (station RB01) were also low (Appendix B, Table B6).

Based on the relatively high aesthetic quality of Dark Brook, the *Aesthetics Use* is assessed as support. However, this use is also identified with "Alert Status" due to the lack of a sufficient riparian zone, the close proximity of commercial development, parking lots and their potential nonpoint sources of pollution (e.g., trash/debris, oil, etc.) which contribute to aesthetic quality degradation (Appendix C).

Dark Brook (MA51-16) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | | Organic enrichment | | Urban runoff |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NOT ASSESSED | | | | |
| Secondary Contact |  | NOT ASSESSED | | | | |
| Aesthetics* |  | SUPPORT | | | | |

* "Alert Status" issues identified.

**RECOMMENDATIONS DARK BROOK (MA51-16)**

- Conduct a review of storm water management practices in the Dark Brook subwatershed —especially those associated with parking lot runoff from the Auburn Mall.

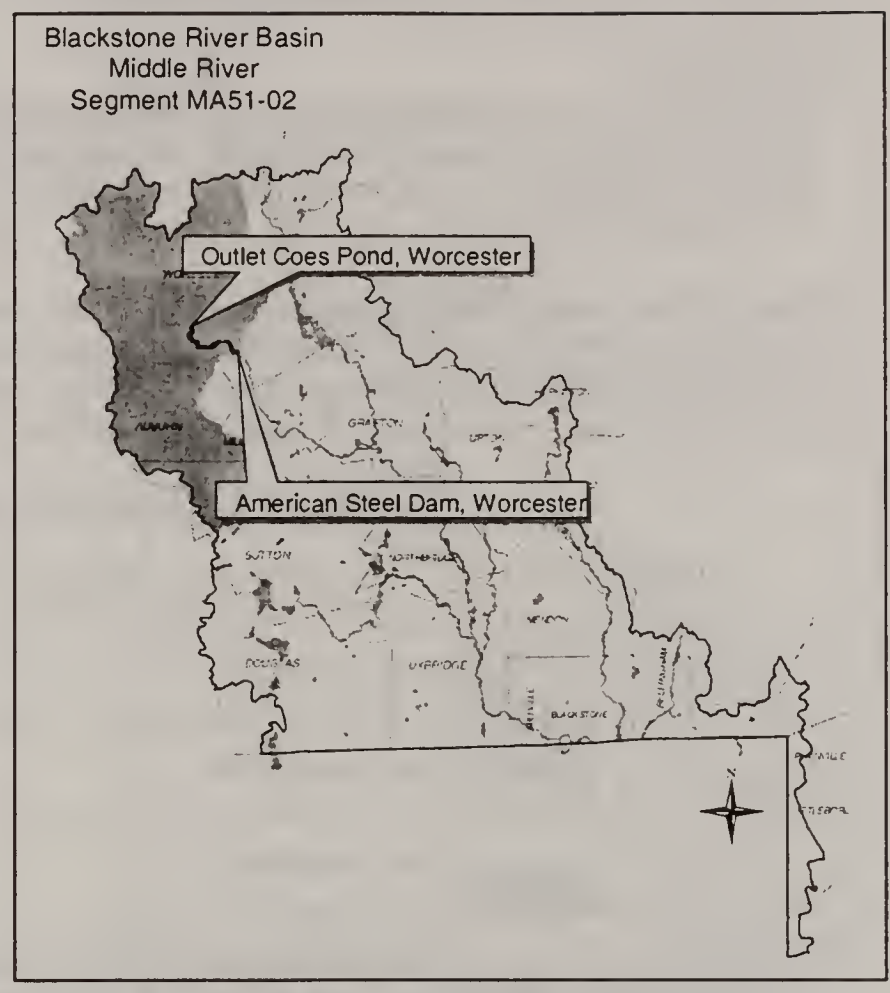
- Restore riparian vegetation to reduce/buffer NPS inputs into this brook.

- Conduct additional fecal coliform bacteria sampling during dry and wet weather conditions to assess the *Primary* and *Secondary Contact Recreational* uses.

- Determine potential impacts of water withdrawals (PWS) on streamflow/habitat in the Dark Brook subwatershed.

## MIDDLE RIVER (SEGMENT MA51- 02)

Location: Outlet Coes Pond, Worcester to American Steel Dam, Worcester.
Segment Length: 2.5 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 44% |
| Residential | 28% |
| Open Land | 7% |

The use assessments of Coes Reservoir and Middle River Pond are provided in the Lakes Assessment section of this report (Tables 5 and 6).

***WMA WATER WITHDRAWAL SUMMARY:***
There are no known regulated WMA water withdrawals in this segment.

***NPDES WASTEWATER DISCHARGE SUMMARY:***
Storm Water Permits:
MAS010002 was issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Coes Pond and the Middle River. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

General storm water permits have been issued to Castrol Heavy Duty Lubricants, Inc. (direct discharge to Middle River) as well as Wire & Metal Separation Systems, Providence & Worcester Railroad, Polar Corporation, and Mass Auto Recycling, Inc. (via Worcester MS4) (Scarlet 2001).

[Note: There are numerous industrial activities currently without permits that are potentially subject to storm water permits. (Scarlet 2001)]

### USE ASSESSMENT

***AQUATIC LIFE***

Habitat and Flow

The DWM benthic macroinvertebrate habitat survey in the Middle River at station BLK00A (located downstream from Interstate 290 and Riley Research Inc., Worcester) identified areas of substantial instream sediment deposition; the sandbars and fine sediments degraded habitat quality (Appendix C).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station (BLK00A), downstream from Interstate 290 and Riley Research Inc., Worcester (Appendix C). When station BLK00A was compared to the regional reference station on the Mumford River (BLK09-8A) the benthic community was found to be 33% comparable or "moderately impaired". The dense filter-feeding macroinvertebrate assemblage at BLK00A appeared to be reflective of the effects of moderate organic enrichment. DWM periphyton samples were collected in this segment of the Middle River. Though not abundant, filamentous algal forms were identified (Appendix C, Table A7).

Chemistry – water

DWM physico-chemical water quality sampling was conducted at three stations on this segment of the Middle River, (TB01 - upstream of the dam at Coes Pond; Middle Riv - downstream of Mill Street Bridge; and BLK00 - upstream of the northern most Millbury Street Bridge) (Appendix B, Figure B1). Samples were collected in June, July and August at the upstream and downstream stations (TB01 and BLK00) and in July at Middle Riv. All three surveys were conducted during dry weather conditions. Water quality data are summarized below (Appendix B, Tables B5 and B6).

*DO*

DO measurements at the upstream station (TB01) ranged from 4.5 to 9.8 mg/L and percent saturation ranged from 51 to 116%. At the downstream station DO ranged from 8.1 to 9.4mg/L and between 90 and 99% saturation. It should be noted, however, that the data do not represent worse-case (pre-dawn) conditions.

*Temperature*

DWM temperature maximum was 25.6ºC.

*pH and Alkalinity*

pH measurements at the upstream station (TB01) ranged from 6.6 to 8.4 SU. At the downstream station (BLK00) the pH was 7.2 SU during all three sampling dates. The maximum alkalinity in the river was 40 mg/L.

*Turbidity*

The maximum turbidity measurement was 4.5 NTU.

*Suspended Solids*

The maximum suspended solids measurement was 3.5 mg/L.

*Ammonia-Nitrogen*

Ammonia-nitrogen maximum was 0.07mg/L.

*Total Phosphorus*

The maximum TP concentration was 0.06 mg/L.

*Hardness*

DWM hardness data from all three stations ranged between 26 and 63 mg/L.

The analysis of the benthic macroinvertebrate data indicated moderate impairment. Based on the benthic macroinvertebrate and water quality data, and habitat degradation, the *Aquatic Life Use* is assessed as non-support. This impairment to the *Aquatic Life Use* appeared to be reflective of the effects of moderate organic enrichment (i.e., elevated pH, supersaturation).

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

Fecal coliform bacteria sampling was conducted by DWM at two stations (TB01, BLK00) in the Middle River (Appendix B, Table B7). The fecal coliform bacteria counts at the upstream station (TB01) ranged from 33 to 560 cfu/100mLs. This station is located above the confluence with Beaver Brook. Station BLK00 was located at the downstream end of this segment, just upstream of the confluence with Mill Brook. Fecal coliform bacteria counts at BLK00 ranged from 920 to 2,400 cfu/100mLs. All samples were collected during dry weather conditions.

Based on the elevated fecal coliform bacteria counts during dry weather and known sources of contamination (illicit sewer connections to Beaver Brook – see segment MA51-07), the *Primary* and *Secondary Contact Recreational* uses are assessed as non-support.

***AESTHETICS***

DWM conducted a habitat assessment (1998) at one station (BLK00A) as part of the benthic macroinvertebrate survey. Visual observations of elevated instream turbidity, probably the result of various forms of urban runoff, were noted during the survey (Appendix C).

Members of the Blackstone Headwaters Coalition conducted a stream team survey along the entire length of the Middle River in 1998. They observed trash/debris along the entire segment. Numerous cleanups of the Middle River including a recent effort in September 2000 indicate that urban runoff is an ongoing problem in this river (Beaudoin 2001).

Based on instream turbidity, and trash/debris from urban runoff, the *Aesthetics Use* is assessed as non-support.

Middle River (MA51-02) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Unknown, organic enrichment, habitat alteration (sedimentation) | | Urban runoff, hydromodification (upstream impoundment), habitat modification | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NON-SUPPORT | Pathogens, turbidity, trash/debris | | Urban runoff, illicit sewer connections | |
| Secondary Contact |  | NON-SUPPORT | Pathogens, turbidity, trash/debris | | Urban runoff, illicit sewer connections | |
| Aesthetics |  | NON-SUPPORT | Turbidity, trash/debris | | Urban runoff | |

**RECOMMENDATIONS MIDDLE RIVER (MA51-02)**

- Investigate the origins (e.g., upstream road crossings, adjacent parking lots) of the substantial instream sediment deposition and remediate as necessary.

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- Continue stream clean-up efforts of the Middle River and encourage/strengthen local stewardship.

- Evaluate opportunities to reduce pollutants from road runoff into the Middle River from State highways (e.g., Route 290) as part of implementing Phase II of the NPDES Storm Water Program.

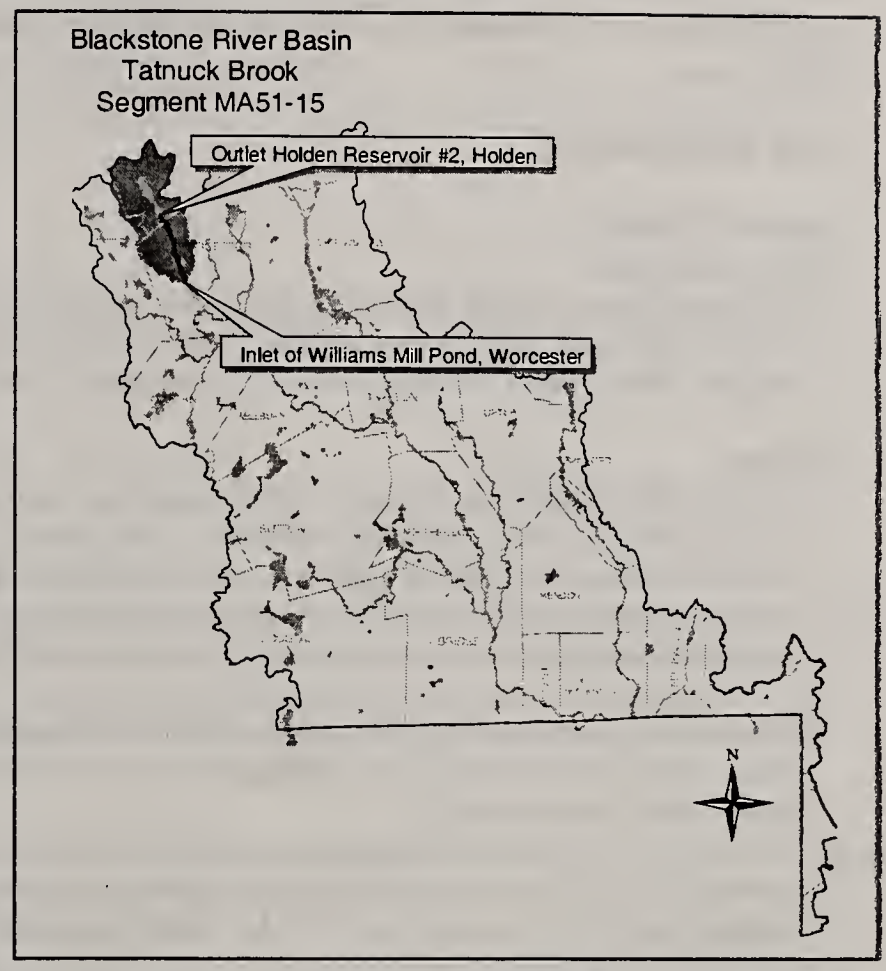
## TATNUCK BROOK (SEGMENT MA51-15)

Location: Outlet Holden Reservoir #2, Holden to inlet Williams Millpond, Worcester.
Segment Length: 4.1 miles.
Classification: Class B.

Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 71% |
| Residential | 17% |
| Open Land | 3% |

The use assessments of Holden Reservoir #2, Cook Pond and Patch Reservoir are provided in the Lakes Assessment section of this report (Tables 5 and 6).




***WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2:***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (# days if < 365) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Tatnuck Country Club | | | 21234803 | C-1 surface water Well #1 | 0.05 MGD (175 days) | 0.04 MGD |
| Worcester Country Club | | | 21234804 | Surface water | 0.1 MGD (210 days) | 0.09 MGD |
| Worcester DPW** | 2348000 | | 21234805 | Holden Reservoir #1 and #2 | 14.22* | 15.33 MGD** |

* Indicates system-wide withdrawal within the Blackstone River Basin

**Worcester Department of Public Works (DPW) is registered (21234805) to withdraw a total of 14.22 MGD from seven surface water sources in the Blackstone River Basin (Holden Reservoirs #1 and 2; Lynde Brook Reservoir, and Kettle Brook Reservoirs #1-4). Worcester DPW is also registered (21134801) to withdraw a total of 9.85 MGD from four surface water sources (Quinapoxet, Kendall, and Pine Hill reservoirs and Asnebumskit Pond) in the Nashua River Basin, for a total system-wide registered withdrawal (both basins) of 24.07 MGD. Water from all sources (both Blackstone and Nashua river basins) is pumped to Holden Reservoir #1 where it is treated and distributed by Worcester's system. The interbasin transfer of water from the Nashua to the Blackstone River Basin is grandfathered since it existed prior to implementation of the Interbasin Transfer Act (IBT) (LeVangie 2000). Worcester DPW has applied for WMA permits in both the Blackstone and Nashua river basins. Their Blackstone River Basin permit request was denied (due to exceedance of the firm safe yield) and Worcester DPW has since appealed the denial which has yet to be settled. A decision has not yet been made on the Nashua River Basin permit application. Although not over their total system-wide (both basins) registered withdrawal (24.07 MGD), Worcester DPW has reported exceedances of their registration threshold volume from the Blackstone River Basin in 1998 and from the Nashua River Basin in 1999. In 1998, the Worcester DPW withdrew 15.33 MGD from their Blackstone River Basin sources but only 7.5 MGD from their Nashua River Basin sources for a total withdrawal of 22.85 MGD. In 1999 however, they reported a withdrawal of 13.33 MGD from their Blackstone River Basin sources and 10.75 MGD from their Nashua River Basin sources for a total withdrawal of 24.08 MGD.

***NPDES WASTEWATER DISCHARGE SUMMARY:***

Storm Water Permits:

MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Patch Reservoir and Tatnuck Brook. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the

Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

A general storm water permit (MAR05A480) has been issued to Worcester Regional Airport (Scarlet 2001).

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

Drainage along Airport Road has been poorly maintained resulting in deep erosion gullies running towards Tatnuck and Fowler brooks. Additionally, unpermitted construction activities at the Scenic Heights Subdivision in 1999 resulted in sediment (clay) input to this subwatershed (Scarlet 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on Tatnuck Brook, upstream from Williams Millpond, Worcester (TB02) (Appendix C). Station TB02 was 67% comparable to the regional reference station (KB10) indicating slight impairment. Periphyton samples were also collected by DWM at this sampling location. While the densities were low, species indicative of organic enrichment were observed (Appendix C, Table A7).

DWM conducted fish population sampling in August 1998 on Tatnuck Brook. The sampling yielded seven species of fish, with the highest density (n= 302) of all the tributaries sampled in the Blackstone River Basin (Appendix C).

The *Aquatic Life Use* is assessed as partial support based on evidence of habitat modification (sedimentation) from urban runoff and a slightly impaired benthic macroinvertebrate community.

### *AESTHETICS*

DWM conducted a habitat assessment (1998) on Tatnuck Brook at the benthic macroinvertebrate station TB02 (Appendix C). Along this reach, localized areas of NPS pollution (dumping of yard waste, trash) were identified.

A shoreline survey of Tatnuck Brook and its tributaries (from Kinneywood Brook to Beaver Brook) was conducted by the Blackstone River Watershed Association in the fall of 1996 (Coffin 24 January 2001). Their Action Plan identified many valuable resources along Tatnuck Brook: wooded areas, a "Quaking Bog" at Cooks Pond, a variety of aquatic habitats (wetlands, streambeds, impoundments), waterfalls, recreation (fishing, swimming, boating, hiking), wildlife, historic features, and scenic overlooks. However, the Stream Team also noted numerous areas impacted by possible failing septic systems/cesspools, questionable discharges, siltation, as well as dump sites for construction debris, yard waste, furniture, appliances, tires, metallic objects, and other trash.

The *Aesthetics Use* is assessed as partial support based on the evidence of nonpoint sources of pollution described above.

Tatnuck Brook (MA51-15) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | PARTIAL SUPPORT | Habitat modification | Organic enrichment | Urban runoff | NPS runoff |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NOT ASSESSED | | | | |
| Secondary Contact |  | NOT ASSESSED | | | | |
| Aesthetics |  | PARTIAL SUPPORT | Trash/debris | | Urban runoff | |

**RECOMMENDATIONS TATNUCK BROOK (MA51-15)**

- Outreach efforts should be made to curb the dumping of trash and yard waste in Tatnuck Brook, and to educate residents of the ecological implication of this type of NPS pollution. Several residential properties abut the stream in areas where the riparian vegetative buffer is reduced, especially the stretch between Patch Reservoir and Williams Millpond in the West Tatnuck/Tatnuck sections of Worcester.

- Work with Tatnuck Brook Stream Team/Coes and Patches Watershed Association to implement their Action Plan recommendations (Coffin 24 January 2001).

- Although the City of Worcester and the Worcester Regional Airport both currently have storm water permits, neither is currently taking responsibility for the drainage along Airport Road. Determine a responsible party and implement storm water runoff controls.

- Evaluate the Worcester Regional Airport's compliance with their storm water pollution prevention plan in term of runway runoff/de-icing chemical controls, etc.

- Enforce storm water regulations on construction projects affecting greater than 5 acres.

- Until the WMA appeal process has been resolved for Worcester DPW's Blackstone River Basin permit request, continue to monitor their withdrawal volumes.

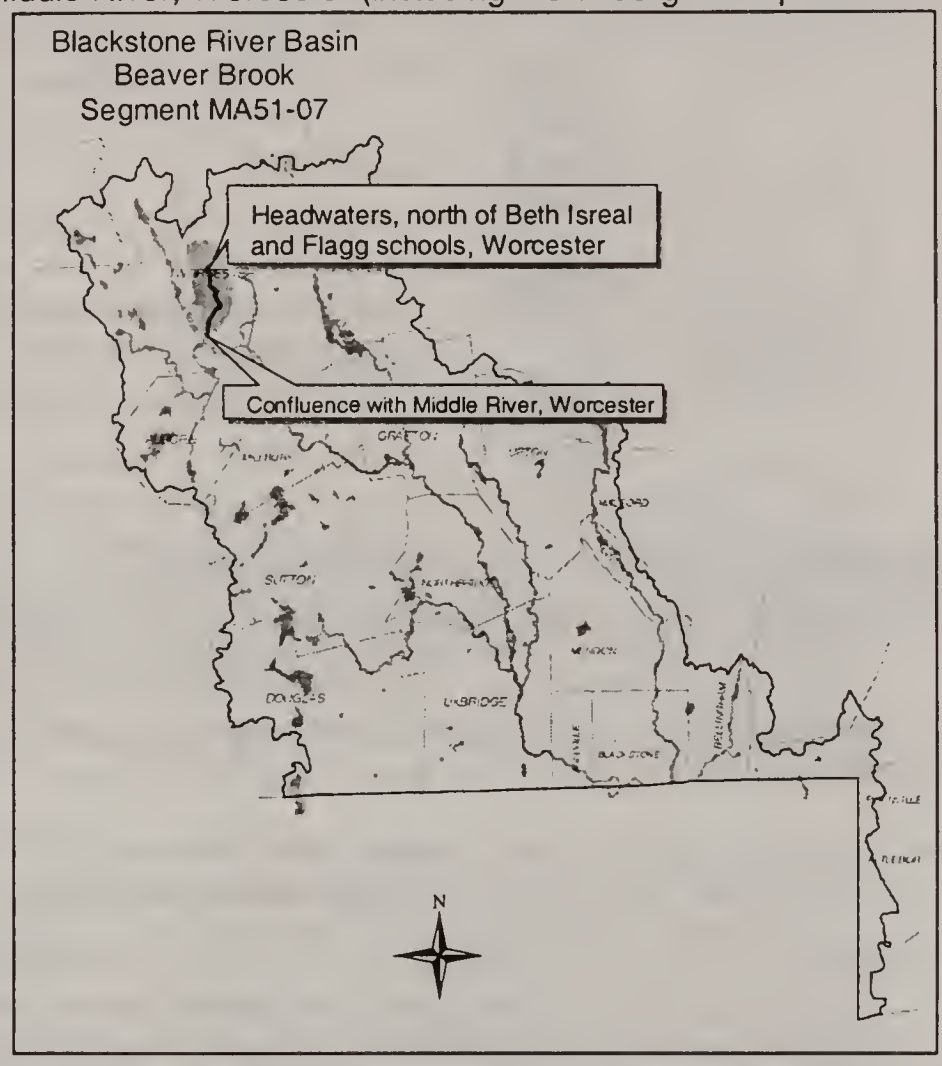
- Evaluate the flow regulation practices in the Holden Reservoir system and collect data to determine flow conditions (particularly low flow) in Tatnuck Brook. Optimize withdrawal practices to maintain minimum flow and to the extent possible natural flow regimes in Tatnuck Brook.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

## BEAVER BROOK (SEGMENT MA51-07)

Location: Headwaters at the outlet of a small unnamed impoundment north of Beth Israel and Flagg Street schools, Worcester to confluence with Middle River, Worcester (including the underground portion of the brook).
Segment Length: 3.0 miles.
Classification: Class B.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Residential | 67% |
| Forest | 13% |
| Open Land | 10% |

Beaver Brook is a small urban stream located entirely within the City of Worcester. The brook is formed by the confluence of a small, unnamed impoundment north of the Beth Israel and Flagg Street schools in a residential area in the northwestern side of the city. It flows southward through increasingly developed residential and commercial areas. Heavy storm water flows resulted in periodic flooding of the surrounding neighborhoods, so the brook was directed to an underground conduit. A short section of the conduit just south of Chandler Street is in disrepair; historic heavy flows resulted in damage to the corrugated metal roof of the pipe, and now a section of the brook at Beaver Brook Park is effectively aboveground. Beaver Brook continues underground through the park, which includes numerous baseball/softball fields, an outdoor skating rink, basketball courts, and a walking trail around the park perimeter. The brook continues underground south of May Street to Maywood Street, passing through a wooded area between a parking lot and a residential area. [The City of Worcester is reviewing the possibility of daylighting this 3500-foot segment between Chandler and Maywood Streets (Appendix E)]. It surfaces south of Maywood Street, and runs aboveground adjacent to the Beaver Brook Parkway. It joins with Tatnuck Brook south of Park Avenue, north of Webster Square.

***WMA WATER WITHDRAWAL SUMMARY:***
There are no known regulated WMA water withdrawals in this segment.

***NPDES WASTEWATER DISCHARGE SUMMARY:***
Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Beaver Brook. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, and the Kettle/Tatnuck Brook subbasin in 2001, Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

The upper 2.7-mile reach of Beaver Brook, between the outlet of the small unnamed impoundment at its headwaters to Maywood Street in Worcester, is culverted and underground. This channel alteration adversely impacts habitat quality.

Biology

In July 1998 a fish kill was documented in Beaver Brook by DWM. A large number of dead and dying fish and crayfish were identified near Webster Square on 10 July. Within a 100-meter reach of the river, approximately 200 white sucker (*Catostomus commersoni)* and bluegill (*L. macrochirus)* were observed dead. Additionally, a dead pumpkinseed (*L. gibbosus*), and fifteen yellow perch (*Perca flavescens*) were identified (Maietta 1998 and Beaudoin 2001).

Chemistry – water

DWM physico-chemical water quality sampling was conducted at three stations in the Beaver Brook subwatershed. Two sampling stations (BB03 - upstream of Flagg Street Worcester; and BB04 - north of Assumption College Driveway, Worcester) were located in the headwaters of Beaver Brook while one station was on Beaver Brook (BB01). The water quality data from the headwater surveys did not indicate any obvious water quality problems (Appendix B, Tables B5 and B6). Results from sampling at BB01 (at the downstream end of this segment) are summarized below.

*DO*

DO measurements ranged from 6.9 to 9.8 mg/L and percent saturation ranged from 65 to 87%. It should be noted, however, that the data do not represent worse-case (pre-dawn) conditions.

*Temperature*

The maximum temperature measurement was 17.2ºC.

*pH and Alkalinity*

Instream pH ranged from 6.3 to 6.8 SU. The maximum alkalinity was 53 mg/L.

*Turbidity*

The maximum turbidity measurement was 2.3 NTU.

*Suspended Solids*

Suspended solids concentrations were BDL.

*Ammonia-Nitrogen*

Ammonia-nitrogen concentrations ranged between 0.23 to 0.39 mg/L.

*Total Phosphorus*

TP concentrations ranged between 0.06 to 0.08 mg/L

*Hardness*

Hardness measurements ranged between 73 and 84 mg/L.

Because of the lack of habitat in the upper 2.7 miles of Beaver Brook (the stream is culverted underground) the *Aquatic Life Use* is assessed as non-support as is the lower 0.3 miles (based on best professional judgement and the evidence of fish kills).

### *PRIMARY CONTACT AND SECONDARY CONTACT RECREATION*

DWM fecal coliform bacteria sampling was conducted at five stations in the Beaver Brook subwatershed. Three stations (BB05 - upstream of Mooreland Street, Worcester; BB03 - upstream of Flagg Street Worcester; and BB04 - north of Assumption College Driveway, Worcester) were located in the headwaters drainage area of this segment (north of the unnamed impoundment). Two stations were

sampled in this segment of Beaver Brook: BB02 (downstream of Maywood Street, Worcester) and BB01 (upstream of Park Avenue, Worcester) (Appendix B, Figure B1).

Fecal coliform bacteria counts from the headwaters drainage area did not exceed 18 cfu/100mLs at the western tributary sampling stations (BB05 and BB03). Counts were as high as 800 cfu/100mLs at the eastern tributary sampling station (BB04). Fecal coliform bacteria counts from the downstream reach of Beaver Brook (BB02) were >6,000 cfu/100mLs while bacteria counts at the most downstream station (BB01) were as high as 8,700 cfu/100mLs with 4 of 5 samples >2000cfu/100mLs.

Based on the elevated fecal coliform bacteria counts, both the *Primary* and *Secondary Contact Recreational* uses are assessed as non-support. Through the City of Worcester DPW's Storm Water Management Program, five illicit sewer connections were identified as discharging to Beaver Brook. All five of these connections were repaired between June and September 1999 (City of Worcester, DPW 2000). However, more such connections may be, as yet, undiscovered and the city continues working to track down illicit connections.

***AESTHETICS***

An overriding objectionable condition (channelized/underground) is not an aesthetic issue according to the use assessment guidance but rather an aquatic life issue related to habitat quality. DWM field survey crews did, however, observe trash, debris and household waste in both June and July 1998, likely associated with illicit sewer connections. Additionally the brook is heavily influenced by storm events.

Based on the objectionable conditions (trash and debris etc.) and best professional judgement the *Aesthetics Use* is assessed as non-support.

Beaver Brook (MA51-07) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life* |  | NON-SUPPORT upper 3.0 miles | Habitat alteration, unknown | | Channelization and habitat modification, unknown | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NON-SUPPORT | Pathogens, trash/debris | | Illicit sewer connections, urban runoff | |
| Secondary Contact |  | NON-SUPPORT | Pathogens, trash/debris | | Illicit sewer connections, urban runoff | |
| Aesthetics |  | NON-SUPPORT | Trash/debris | | Urban runoff, Illicit sewer connections | |

* "Alert Status" issues identified.

**RECOMMENDATIONS BEAVER BROOK (MA51-07)**

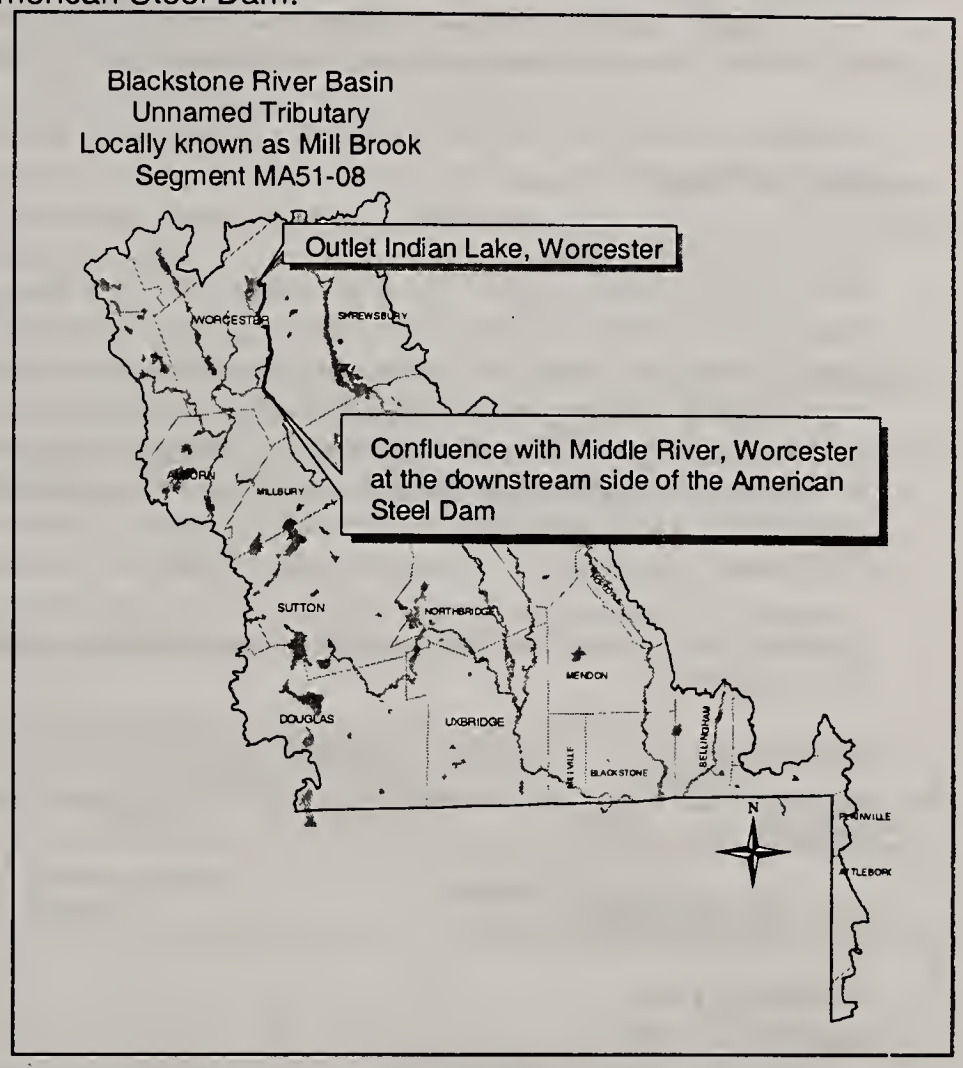
- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- Implement the recommendations from the Beaver Brook Daylighting Feasibility Study (Project 99-01/MWI) (Appendix E) and the Blackstone River Watershed Massachusetts Watershed Initiative Five Year Action Plan (Jobin 2000).

- Determine potential impacts of water withdrawals (PWS) on streamflow/habitat in the Beaver Brook subwatershed.

## UNNAMED TRIBUTARY - "MILL BROOK" (SEGMENT MA51-08)

Location: (Also known as "Mill Brook") Outlet Indian Lake, Worcester to confluence with Middle River, Worcester at the downstream side of the American Steel Dam.
Segment Length: 3.0 miles.
Classification: Class B, Warm Water Fishery, CSO.




Land use estimates for this subwatershed were not available through MassGIS. According to the Worcester DPW, approximately 60% of this subwatershed is comprised of impervious surfaces (Buckley 2000).

The use assessments of Indian Lake and Salisbury Pond are provided in the Lakes Assessment section of this report (Tables 5 and 6).

From the outlet of Indian Lake, Mill Brook receives the flow from Weasel and Kendrick brooks. Together these flows are gathered, (near Boylston and West Boylston streets and Route 190, Worcester) into twin box culverts flowing south surfacing in Salisbury Pond. From the outlet of Salisbury Pond, Mill Brook enters into an old stone-lined oval culvert (known as "Old Mill Brook") which continues underground to Lincoln Square. At Lincoln Square the flow of Mill Brook is diverted from further travel through the "Old Mill Brook" culvert. It continues in a new box culvert parallel to the "Old Mill Brook", continuing in a southerly direction to Grabowski Square. Down gradient from Grabowski Square, Mill Brook again flows through the "Old Mill Brook" stone culvert south to its confluence with the Middle River (just downstream of the American Steel Dam) forming the Blackstone River.

[NOTE: Just downstream from Lincoln Square, the "Old Mill Brook" culvert receives combined sewer inflow. The combined sewer flow is shunted at Grabowski Square out of the "Old Mill Brook" culvert to the CSO Plant. The flow is typically (dry weather) pumped to the Upper Blackstone WPAD for treatment. When necessary (storm events >0.5 inches of rain), the CSO facility provides primary treatment, and treated CSO is discharged into Mill Brook.]

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Cincinnati Milacron-Heald Corp. | | | 21234802 | Well #1 (Boiler Room)<br>Well #2 (Back Gate) | 0.49 MGD | Facility is closed |
| Norton Company | | 9P21234802 | 21234801 | Brooks Street Well<br>Higgins Street Well<br>New Bond Street Well<br>Ararat Street Well<br>C Street Well | 0.57 MGD | 0.3 MGD |

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

MA0102997 issued to Worcester CSO Treatment Facility gives authorization to discharge (November 1990) via outfall #001 a maximum of 350 MGD of screened and disinfected (chlorine) combined sewer overflow to "Mill Brook".

New England Plating Company (MA0005088) is authorized to discharge (February 2000) treated wastewater monthly average flow of 0.20 MGD and a maximum daily flow of 0.30 MGD via outfall #001 to Mill Brook. The permit limit for whole effluent toxicity is $LC_{50} \geq 100\%$. The permit requires toxicity testing for two test organisms (*Ceriodaphnia dubia* and *Pimephales promelas*). $NH_3$-N effluent samples collected as part of the toxicity testing requirement ranged from 1.36 to 24.96 mg/L.

MA0001112 Wyman-Gordon Company, Worcester. This facility has been closed and the site is now a "Brownfield Site".

Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers to Indian Lake, "Mill Brook" and its tributaries (Weasel and Kendrick brooks). The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003 (CDM 1999). Additionally, DPW responds to complaints and/or known hotspots as needed, including the identification of illicit sewer connections, known to be numerous in this drainage area.

General storm water permits have been issued to Romtek/Kervick and Wright Line (in the subwatershed) (Scarlet 2001).

[Note: Norton, Co., Worcester also has an NPDES permit (MA0000817) to discharge uncontaminated cooling water via seven outfalls (001 – 007) to Weasel Brook, a tributary to "Mill Brook". The permit was issued in July 1975.]

**USE ASSESSMENT**

***AQUATIC LIFE***

Habitat and Flow

The entire length of "Mill Brook" is culverted and underground except where it surfaces in Salisbury Pond. This channel alteration adversely affects habitat quality. Heavy sedimentation from upstream sources is also causing the formation of sand bars in Salisbury Pond where the water depth has been reduced to less than two inches (Beaudoin 2001).

Toxicity

*Effluent*

The New England Plating Company has conducted acute whole effluent toxicity tests on a quarterly basis from March 1996 to February 2000. In 16 of 17 tests performed on *C. dubia* the $LC_{50}$ was below 100% effluent ranging from three to 93%. In 10 of the tests the $LC_{50}$ was less than 50% effluent. In six of 17 tests performed on *P. promelas* the $LC_{50}$ was below 100% effluent ranging from 19 to 73%.

Chemistry – water

DWM physico-chemical water quality sampling was conducted at four paired stations on Mill Brook (the west culvert and the east culvert) between the outlet of Indian Lake and Salisbury Pond (Appendix B, Table B6). Hardness, conductivity and nitrates were higher in the eastern conduit than the western conduit. Suspended solids and turbidity measurements in the eastern conduit were lower than in the western conduit.

The physical alteration (underground and culverted) of Mill Brook resulted in a reduction of habitat available for aquatic life thus impairing (non-support) the *Aquatic Life Use* for its entire length. Effluent toxicity from the New England Plating Co. discharge is also a problem.

***FISH CONSUMPTION***

DWM conducted fish toxics monitoring of Salisbury Pond in May 2000. Composite samples of yellow perch, largemouth bass, carp, and yellow bullhead were submitted to WES for metals, PCB and organochlorine pesticide analysis. In addition the yellow bullhead sample will be analyzed for semi-volatile organic compounds. The complete dataset is not yet available (Maietta 2000).

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

The City of Worcester DPW Storm Water Management Program, Illicit Connections Program identified five illicit sewer connections discharging to Mill Brook, of which one of the largest was repaired in October 1999 (City of Worcester DPW 2000). The remaining illicit connections are being scheduled for repair. When needed, DEP has partnered with the City to facilitate the repair process.

Although no recent instream fecal coliform bacteria data were available, the aesthetic quality degradation described below, as well as the illicit sanitary sewage discharges into Mill Brook impair (non-support) both the *Primary* and *Secondary Contact Recreational* uses.

***AESTHETICS***

An overriding objectionable condition (channelized/underground) is not an aesthetic issue according to the use assessment guidance but rather an aquatic life issue related to habitat quality. Trash is a constant problem observed in Salisbury Pond, as are frequent oily sheens and a heavy petroleum odor noted at the pond's inlet and outlet (Beaudoin 2001). Additionally there are known illicit sewer connections to this brook.

Based on the presence of trash, oil sheens and odors and best professional judgement (illicit sewer connection), the *Aesthetics Use* in Mill Brook is assessed as non-support.

Unnamed Tributary "Mill Brook" (MA51-08) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Habitat alteration, toxicity | | Channelization and habitat modification, industrial point source | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NON-SUPPORT | Oil and grease, odor | | Urban runoff ,Illicit sewer connections | |
| Secondary Contact |  | NON-SUPPORT | Oil and grease, odor | | Urban runoff ,Illicit sewer connections | |
| Aesthetics |  | NON-SUPPORT | Oil and grease, odor, trash/debris | | Urban runoff ,Illicit sewer connections | |

**RECOMMENDATIONS UNNAMED TRIBUTARY "MILL BROOK" (MA51-08)**

- It is known that there are faulty sewer systems in the headwaters of Mill Brook including illicit sewer connections. The City of Worcester is aware of this situation and has been highly successful in identifying these illicit discharges. However, building owners are not always expedient in rectifying the situation despite the city's offer to cover 50% of the cost of the repairs (provided the repairs are conducted by the subcontractors approved by the City). It is recommended that the DEP continue to assist the City of Worcester and the Blackstone Watershed Team (Jobin 2000) where needed in addressing the repairs of illicit sewer connections.

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- Conduct an upstream/downstream fecal coliform bacteria evaluation of the Worcester CSO discharge to evaluate the effectiveness of the treatment facility.

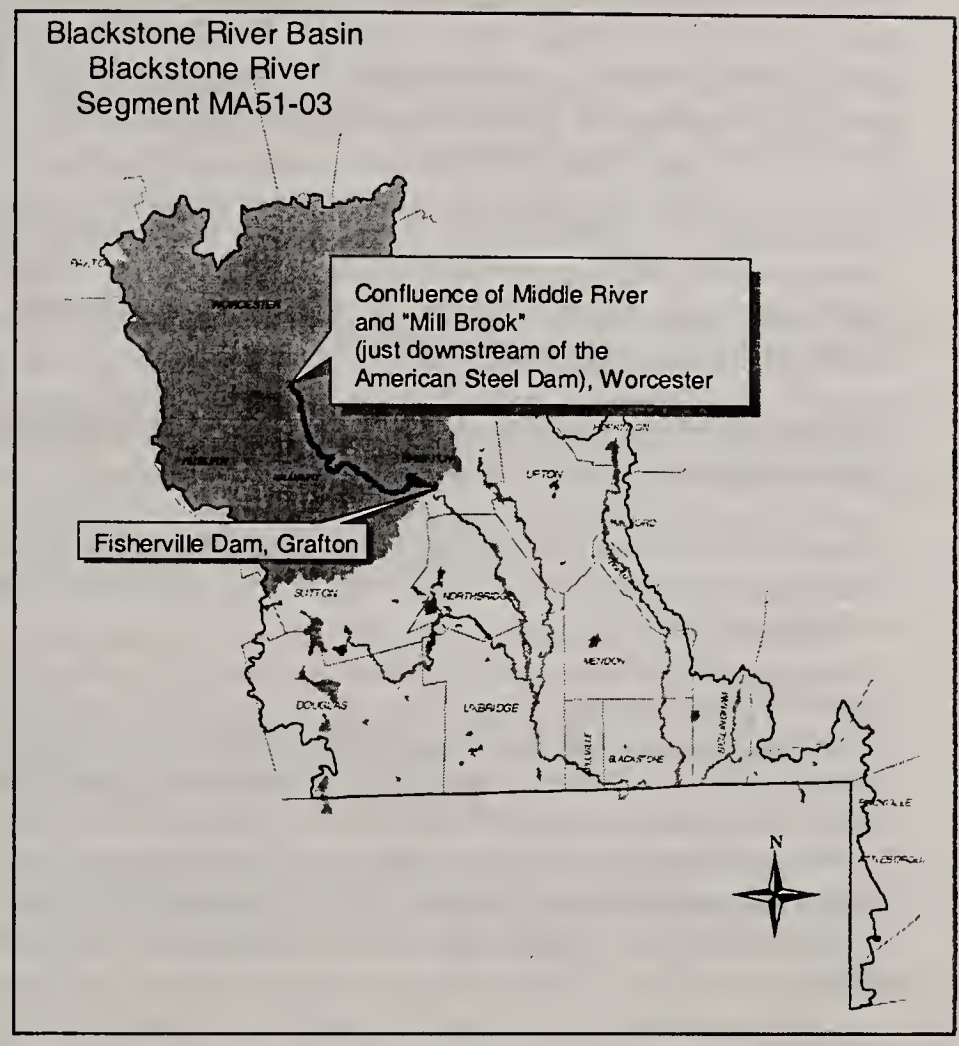
- New England Plating is currently not meeting their effluent toxicity limits and therefore the company should continue to evaluate pollution prevention and/or treatment alternatives to reduce whole effluent toxicity. The facility should collect water from Mill Brook upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 80% at 7-day), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of Mill Brook.

- The NPDES permit (MA0000817) for the Norton, Co., Worcester needs to be reissued with appropriate limits and monitoring requirements including requirements for storm water management.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## BLACKSTONE RIVER (SEGMENT MA51-03)

Location: Confluence of Middle River and "Mill Brook" (just downstream of the American Steel Dam), Worcester to Fisherville Dam, Grafton.
Segment Length: 9.0 miles.
Classification: Class B, Warm Water Fishery, CSO.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 45% |
| Residential | 26% |
| Open Land | 8% |

The use assessment of Fisherville Pond is provided in the Lakes Assessment section of this report (Table 6).

A major highway construction project (Route 146/ Mass Pike) is underway in this segment of the Blackstone River in Millbury.

Fish population surveys in the Blackstone River were conducted by DFWELE in July/August 1973 (Project No. F-36-R-6) (DFWELE undated). Additionally, Cold Spring Brook, Sutton and Cronin Brook in Grafton, tributaries to this segment of the Blackstone River, were identified by DFWELE as supporting native brook trout based on surveys conducted in 1985 and 1984, respectively (McLaughlin 2001).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (#days if <365 noted) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Wilkinsonville Water District | 2290014 | 9P421229001 | | 03G Well #3 (Cold Spring Brook Subwatershed) | 0.2 MGD | 0.16 MGD |
| Grafton Water District | 2110000 | 9P421211004 | 21211004 | 110-05G Follette St. Well<br>110-02G Worcester St. Well | 1.11 MGD* | 0.99 MGD* |
| Mass. American Water Co., Millbury | 2186000 | 9P21218601 | 21218602 | 2186000-01G<br>2186000-02G<br>2186000-03G<br>2186000-04G | 2.02 MGD | 1.65 MGD |
| Polyclad Laminates, Inc. | | | 21218603 | S Polyclad intake | 0.11 MGD | 0.01 MGD |
| Concrete Service Inc.* | | | 21218604 | Well #2<br>C-1 | 1.08 MGD*<br>(264 days) | 0.43 MGD in 1996* |
| Pleasant Valley Country Club | | | 21229002 | Cogan Pond | 0.16 | 0.18 MGD** |

* Indicates system-wide withdrawal, **Withdrawal did not exceed registration amount by more than 0.1 MGD (WMA threshold)

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Upper Blackstone Water Pollution Abatement District (UBWPAD), permit number MA0102369, is authorized to discharge (September 1999) 56 MGD of treated wastewater via outfall #001 to this segment of the Blackstone River. It should be noted, however, that the facility has appealed their permit limits for

metals, phosphorus and ammonia-nitrogen which would require year round nitrification (Mounce 2000). The company's permit limits for whole effluent toxicity are $LC_{50} \geq 100\%$ and CNOEC $\geq$ 90% for two test organisms, *C. dubia* and *P. promelas*. The UBWPAD has a TRC limit of 0.012 mg/L and implemented dechlorination (sodium bisulfite) within the last four years. TRC concentrations in the effluent were above the permit limits in three of the 15 tests. The facility has a monthly average effluent ammonia-nitrogen limit of 5 mg/L from 1 June through 15 June and a 2 mg/L limit from 15 June through 3 October. For the remainder of the year the facility is required to monitor only. Effluent ammonia-nitrogen concentrations ranged from 0.12 to 13.5 mg/L

Millbury WWTP (MA0100650) is authorized to discharge (September 1999) 1.2 MGD of treated wastewater to this segment of the Blackstone River. Their permit limit for whole effluent toxicity is $LC_{50} \geq$ 100% using two test organisms, *C. dubia* and *P. promelas*. Their TRC limit is 0.58 mg/L. The facility is scheduled to be connected to UBWPAD.

Lewott Corporation (MA0028592) is authorized to discharge (September 1992) non-contact cooling water to this segment of the Blackstone River.

Polyclad Laminates (MA0027618) has installed a closed loop system so therefore the facility no longer discharges non-contact cooling water to this segment of the Blackstone River. The permit was inactivated in October 1998.

Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers to the Blackstone River. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

***OTHER:***
Hazardous Waste Sites:
High levels of heavy metals (primarily lead) and petroleum compounds have been detected in sediment along the banks of this segment of the Blackstone River. Two areas of know contamination, are 1) an approximate 100-150 foot reach of riverbank located just upstream of McCracken Road, and 2) a small reach of riverbank located near a newly constructed bridge abutment located approximately 500-1,000 feet downstream of McCracken Road. Both of these areas are currently in assessment phases. The area upstream of McCracken Road is scheduled for remediation (contaminated sediment will likely be removed) by the Mass Highway Department (MHD).

Other contaminated properties exist along the Route 146 corridor along the Blackstone River. MHD may implement remedial actions (where required) that will clean up contaminated groundwater and soil that is currently impacting the river.

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

Much of the Blackstone River between its confluence with "Mill Brook" and McCracken Road in Millbury has been channelized (Cohen 2001). Habitat quality in this segment of the Blackstone River has also been adversely affected by sediment inputs from the Route 146 Construction Project. Heavy sand deposits were also noted by DWM in both benthic macroinvertebrate sampling reaches (see below BLK01 and BLK02).

There are extreme fluctuations in streamflow in this segment of the Blackstone River during storm events. These fluctuations are a result of the urban nature of the subwatershed (impervious surfaces), discharge at the UBWPAD and, when discharging, the Worcester CSO Facility. Additionally, the water level in Fisherville Pond (the lower end of this segment) has been significantly lowered due to unsafe

conditions at the dam: the gates have been fixed in the open position (Beaudoin 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at two stations on this segment of the Blackstone River (Appendix C):

- BLK01, downstream from Millbury St. approximately 0.4 miles downstream from the confluence with Mill Brook, Worcester (served as the downstream test station for the Worcester CSO facility and as an upstream reference station for the Upper Blackstone WPAD discharge)
- BLK02, downstream from McCracken Rd., Millbury (served as the downstream test station for the Upper Blackstone WPAD discharge)

The benthic community at station BLK01 was compared to the upstream reference station in the Middle River (BLK00A) in part to evaluate the instream effects of the Worcester CSO facility discharge. The benthic community was found to be 30% comparable or "moderately impaired" (Appendix C, Table A3). To evaluate the effects of the UBWPAD discharge, the benthic communities upstream (BLK01) and downstream (BLK02) of the discharge were compared and found to be non-impaired (95% comparable). However, when these communities were compared to the regional reference station on the Mumford River, they were both found to be severely impaired (Appendix C, Table A2).

DWM periphyton samples were collected in this segment of the Blackstone River at both benthic macroinvertebrate sampling locations. Instream algal growth at both the upstream and downstream stations was minimal. The periphyton community in the upstream station was dominated by diatomaceous algae and the downstream station was dominated by filamentous green alga, both of which are known to thrive in organically enriched conditions (Appendix C).

A preliminary baseline ecological and human health risk characterization was conducted in the Fisherville Pond/Blackstone River System in Grafton by McLaren/Hart Environmental Corp on behalf of the US ACOE in 1996 (US ACOE 1997). This study included both fish community and quantitative benthic invertebrate surveys. The fish survey indicated a moderately diverse and abundant community in this system although the community was dominated by pollution tolerant species (white sucker, golden shiner and carp). Aquatic earthworms followed by chironomid midges, damselflies, snails and amphipods dominated the benthic macroinvertebrate community. The ACOE study indicated that while degradation was not severe, the impacts to the biological communities were likely the result of a combination of poor water quality and sediment quality and a less than stable pool height (US ACOE 1997).

Toxicity

*Effluent*

The UBWPAD has conducted whole effluent toxicity tests on a quarterly basis between January 1996 and April 2000 on two test organisms (*C. dubia* and *P. promelas*). Acute toxicity was only detected in the January and April 1996 tests and none has been exhibited since. The CNOEC permit limit was not met in seven of 15 C. *dubia* test events (25 to 50% effluent) and in four of 14 *P. promelas* test events (12.5 to 50% effluent).

*Ambient*

The UBWPAD has conducted ambient toxicity tests on a quarterly basis between January 1996 and April 2000 on two test organisms (*C. dubia* and *P. promelas*). River water was collected from the Blackstone River at the bridge on Millbury Street in Worcester. Survival (7-day) of *C. dubia* was reported as being ≥80%, with the exception of two test events in July 1999 when survival in the river water was zero. Survival of *P. promelas* exposed (7-day) to river water ranged between 22 and 100%.

Chemistry – water

UBWPAD collected Blackstone River water (from the Millbury Street) for use as dilution water in their whole effluent toxicity tests. Fifteen tests (for pH, suspended solids, ammonia nitrogen, TRC, and hardness) were conducted between January 1996 and April 2000 (TOXTD database). DWM physico-chemical water quality sampling was conducted at two stations on this segment of the Blackstone River (Appendix B, Tables B5 and B6). Water quality sampling locations were collocated with DWM benthic macroinvertebrate stations BLK01 and BLK02.

*DO*

DO measurements at the upstream station (BLK01) ranged from 8.2 to 8.8 mg/L and saturation ranged from 86 to 97%. At the downstream station (BLK02) DO was 8.2 mg/L (90% saturation). It should be noted, however, that the data do not represent worse-case (pre-dawn) conditions.

*Temperature*

DWM temperature maximum was 22.0ºC.

*pH and Alkalinity*

UBWPAD ambient pH measurements ranged between 6.6 and 8.3 SU. DWM's pH data were within the same range. DWM alkalinity at both sampling stations ranged between 35 and 47 mg/L.

*Turbidity*

The maximum turbidity measurement was 2.9 NTU.

*Suspended Solids*

The suspended solids concentrations reported by UBWPAD ranged between 2.5 and 9.4 mg/L, within the same range as DWM's data.

*Ammonia-Nitrogen*

Upper Blackstone WPAD ambient $NH_3$-N concentrations ranged between 0.08 to 0.20 mg/L. The DWM ammonia nitrogen data were within the same range with highest concentration downstream of the treatment plant.

*Phosphorus*

DWM phosphorus data ranged did not exceed 0.06mg/L at the upstream station (upstream of the UBWPAD) while the single measurement in July at the downstream station (BLK02) was 0.34 mg/L.

*Total Residual Chlorine*

All TRC concentrations reported in the UBWPAD toxicity testing reports were below the minimum quantification level of 0.05 mg/L.

*Hardness*

Hardness measurements reported in the UBWPAD toxicity test reports ranged between 38 and 102 mg/L. The DWM hardness measurements were within the same range.

Chemistry – sediment

A preliminary baseline ecological and human health risk characterization was conducted at Fisherville Pond by McLaren/Hart Environmental Corp on behalf of the US ACOE (US ACOE 1997). This study included acid volatile sulfides (AVS)/simultaneously extracted metals (SEM) at three stations in this segment of the Blackstone River. All samples had SEM/AVS ratios greater than one indicating the divalent metal concentrations in these sediments may be toxic to sediment biota.

Habitat degradation in the form of instream sediment deposition, a severely impaired benthic macroinvertebrate community, evidence of instream toxicity, water and sediment quality degradation related to organic enrichment, metals and other toxicants, impair (non-support) the *Aquatic Life Use* in this segment of the Blackstone River.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

In July 1998 DWM collected fecal coliform bacteria samples at two stations on this segment of the Blackstone River (Appendix B, Table B7):

- BLK01, upstream from Millbury St.
- BLK02, upstream from McCracken Rd., Millbury

The fecal coliform bacteria data at the upstream station (BLK01) ranged from 580 cfu/100mLs to 2,040 cfu/100mLs. The count at the downstream station was above 400 cfu/100mLs. All samples were collected during dry weather conditions.

The City of Worcester DPW Storm Water Management Program, Illicit Connections Program identified an illicit sewer connection discharging to this segment of the Blackstone River that was repaired in November 1999 (City of Worcester DPW 2000). It should also be notes that the Worcester CSO Treatment Facility discharges screened and disinfected combined sewer overflow (up to 350 MGD during storm events) to "Mill Brook" at the upstream end of this segment.

Based on the elevated fecal coliform bacteria counts during dry weather conditions the *Primary Contact Recreational Use* is assessed as non-support. The poor aesthetic quality (described below) of this segment of the Blackstone River, also impairs the *Primary* and *Secondary Contact Recreational* uses (assessed as non-support).

***AESTHETICS***

NPS pollution was evident at both DWM benthic macroinvertebrate sampling locations in the form of trash and debris. The dumping of debris from the Millbury Street road crossing (BLK01) and the adjacent stream banks appears to be a historical and ongoing problem. Moderate levels of turbidity were also observed. Large deposits of excavated materials adjacent to the river from the Route 146 Construction Project was the most likely cause of sediment inputs to this portion of the river.

Based on the above information (trash/debris, turbidity and objectionable deposits), the *Aesthetics Use* is assessed as non-support.

Blackstone River (MA51-03) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Habitat alteration, organic enrichment, nutrients, toxicity | | Unknown, channelization, habitat modification, municipal point source, CSO, urban runoff | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NON-SUPPORT | Pathogens, trash/debris, turbidity | | Urban runoff, illicit sewer connection | |
| Secondary Contact |  | NON-SUPPORT | Pathogens, trash/debris, turbidity | | Urban runoff, illicit sewer connection | |
| Aesthetics |  | NON-SUPPORT | Trash/debris, turbidity | | Urban runoff, illicit sewer connection | |

**RECOMMENDATIONS BLACKSTONE RIVER (MA51-03)**

- Recommendations quoted from Appendix C – 1998 DEP DWM Biomonitoring Technical Memorandum.

  *BLK01*

  Organic pollutant loadings entering this portion of the Blackstone River from Mill Brook continue to compromise water quality and biological integrity at BLK01. In addition, the conspicuous absence of filter-feeders and the extremely low abundance of invertebrates suggests the presence of a toxicant (i.e., ammonia, and/or metals toxicity). Again, Mill Brook—and especially the Worcester CSO facility—probably is the source of potential toxic stressors. Instream toxicity testing, as well as toxicity analyses of the CSO discharge, should be conducted to confirm this. Sediment toxicity at BLK01 is recommended as well.

  *BLK02*

  As has historically been the case, the severely impaired benthic community here is structured in response to severe organic enrichment and possible toxicants, and is probably most impacted by the UBWPAD discharge.... Significant deposits of sand compromise biological integrity at BLK01 as well, and probably originate from recent highway construction activities (i.e., new exit and ramp construction) just upstream from the sampling reach. An investigation into the efficacy of pre-existing nonpoint source pollution-related Best Management Practices (BMPs), or the implementation of new BMPs, associated with the highway interchange project is recommended.

- The MHD, Massachusetts Turnpike Authority, and the City of Worcester should implement BMPs to reduce road sand and other urban runoff inputs to the Blackstone River Basin (i.e., storm water permitting requirements).

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- The UBWPAD (MA0102369) should continue to collect water from the Blackstone River upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 80% at 7-day), then the river water must still be utilized as a test control and not as diluent. If toxicity test results continue to violate permit limits (frequency and severity of violations considered), a toxicity identification and reduction evaluation should be conducted.

- Restore and/or establish vegetated riparian buffers along the Blackstone River (especially in areas impacted by the Route 146 Construction Project) to help absorb and filter runoff before it reaches the river.

- Work with the Blackstone Watershed Team and continue to implement remedial actions that will clean up contaminated groundwater and soil, currently impacting the Blackstone River (Jobin 2000).

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

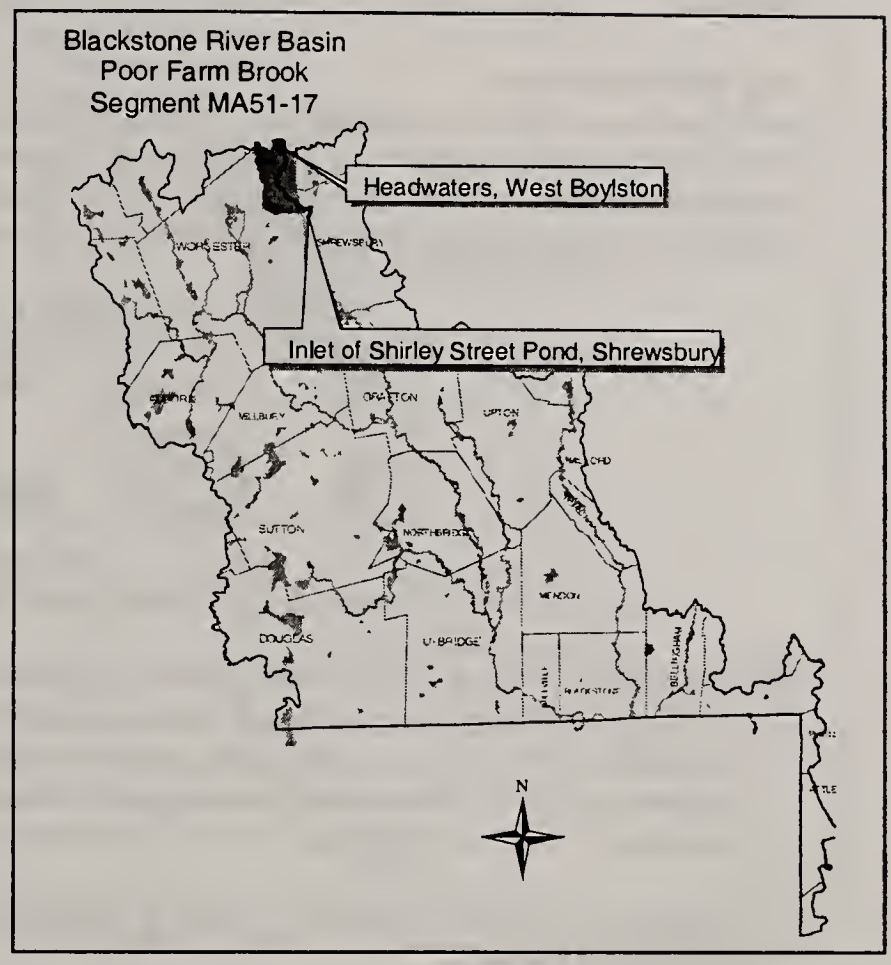
- In the next revision of the Massachusetts Surface Water Quality Standards, consider (in consultation with DFWELE) designating the following rivers in this subwatershed as cold water fisheries: Cold Spring, Sutton, and Cronin brooks.

## POOR FARM BROOK (SEGMENT MA51-17)

Location: Headwaters, West Boylston to the inlet of Shirley Street Pond, Shrewsbury.
Segment Length: 3.6 miles.
Classification: Class B.

Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Residential | 37% |
| Forest | 33% |
| Open Land | 18% |




The use assessments of City Farm and Shirley Street ponds are provided in the Lakes Assessment section of this report (Tables 5 and 6).

A shoreline survey of Poor Farm Brook was conducted in November 1998 in conjunction with the Blackstone Headwaters Coalition. A golf course, horse farm and well fields were noted as being in close proximity to the brook. While the water column was generally clear, trash and debris was observed along the entire brook. The lower reach of Poor Brook, from the outlet of City Farm Pond to the mouth at Lake Quinsigamond, was dry (Coffin 24 January 2001).

In July 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in Poor Farm Brook. Five species of fish including, in order of dominance, blacknose dace, white sucker, brook trout, tesselated darter and an individual brown bullhead were collected (DFWELE undated).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (# days if <365) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Worcester Sand and Gravel, Inc | | 9P21227102 | | Well #1 Surface water | 0.57 MGD (270) | 0.26 MGD |
| Morningdale Water District | 2039001 | | 21203901 | 039A02G Well #2<br>039A01G Well #1 | 0.17 MGD | 0.17 MGD |
| Shrewsbury Water & Sewer Department | 2271000 | 9P21227101 | 21227101 | 2271000-03G<br>2271000-05G<br>2271000-04G<br>2271000-06G<br>2271000-01G<br>2271000-02G<br>2271000-07G | 3.65 MGD | 3.88 MGD* |
| Worcester Department Public Works | 2348000 | | 21234805 | Shrewsbury Well | Emergency only | None |

* exceeds the WMA threshold of 0.1 MGD and regulatory actions are currently underway (Beaudoin 2001)

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Poor Farm Brook. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000,

Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999).

**USE ASSESSMENT**

Too little current data/information were available to adequately assess the designated uses in Poor Farm Brook; therefore this segment is not assessed. However, Poor Farm Brook, from the outlet of City Farm Pond to the mouth at Lake Quinsigamond, was dry in November 1998 and trash and debris were noted along its entire length, therefore both the *Aquatic Life* and *Aesthetic* uses are on "Alert Status".

Poor Farm Brook (MA51-17) Use Summary Table

| Aquatic Life* | Fish Consumption | Primary Contact | Secondary Contact | Aesthetics* |
|---|---|---|---|---|
|  |  |  |  |  |
| Not Assessed | | | | |

* "Alert Status" issues identified

**RECOMMENDATIONS POOR FARM BROOK (MA51-17)**

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- Continue to review Shrewsbury Water & Sewer Department's compliance with their WMA registration/permit.

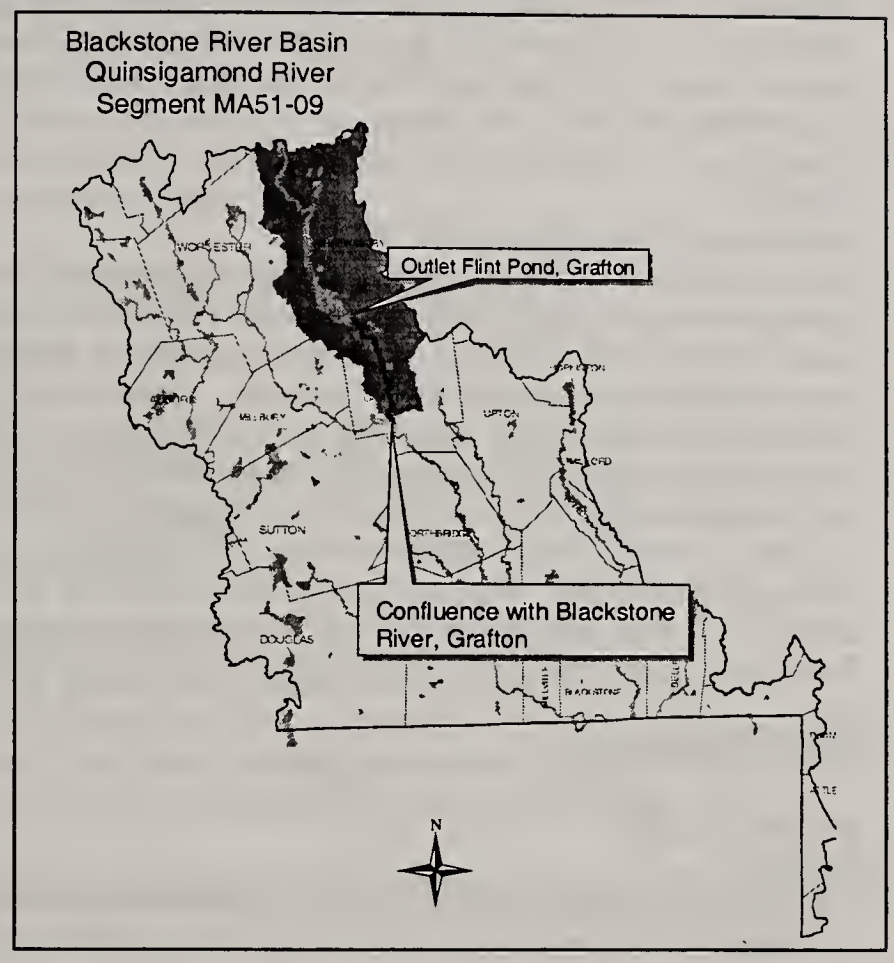
- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- Work with the Blackstone Headwaters Coalition and other local/regional groups to conduct a stream cleanup effort along Poor Farm Brook.

- Collect additional data to determine the frequency, duration and spatial extent of the low flow conditions Poor Farm Brook.

## QUINSIGAMOND RIVER (SEGMENT MA51-09)

Location: Outlet Flint Pond, Grafton to confluence with Blackstone River, Grafton.
Segment Length: 5.3 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 42% |
| Residential | 28% |
| Open Land | 9% |

The use assessments of Flint Pond, Hovey Pond, Lake Ripple, and Lake Quinsigamond are provided in the Lakes Assessment section of this report (Tables 5 and 6).

In July 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in the Quinsigamond River. Eight species of fish including, in order of dominance, yellow bullhead, bluegill, fallfish, pumpkinseed, redfin pickerel, white sucker, tesselated darter an individual black crappie were collected (DFWELE undated). Additionally, Axtell Brook in Grafton, a tributary to the Quinsigamond River, was identified by DFWELE as supporting native brook trout based on a survey conducted in 1982 (McLaughlin 2001).

***WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Wyman-Gordon Company | | | 21211001 | Well #4<br>Well #3A<br>Well #2<br>Well #1<br>Hovey Pond/Quinsigamond | 3.38 MGD | 0.02 MGD |
| Concrete Service Inc.* | | | 21218604 | Wash Water Pump #2<br>Concrete Mix Plant #1<br>Domestic Well #3 | 1.08 MGD* (264 days) | 0.29 MGD in 1996 |
| Grafton Water District * | 2110000 | 9P421211004 | 21211004 | 2110000-03G<br>2110000-04G | 1.11 MGD* | 0.99 MGD* |

* Indicates system-wide withdrawal

***NPDES WASTEWATER DISCHARGE SUMMARY:***

Wyman-Gordon Company, Grafton (MA0004341) discharges (permit issued June 1997) via multiple outfalls including #001, #010, and #008. When there is a hydraulic overflow of the Runoff Management Facility, outfall 010 discharge to Quinsigamond River (at flows up to 1.4 cfs), and at higher flows outfall 001 discharges to a tributary to the Quinsigamond River. The facility is required to conduct an acute whole effluent toxicity test ($LC_{50} \geq 100\%$) once a quarter if/when a discharge occurs. The facility is also authorized to discharge storm water via Outfall 008 to Flint Pond via Bonny Brook. At this outfall, the company is required to monitor whole effluent toxicity at the frequency of once per year.

Storm Water Permits:
MAS010002 issued to the City of Worcester DPW in September 1998 and gives authorization to discharge from all new or existing storm sewers into Lake Quinsigamond. The permit requires a storm water management plan. Worcester is rotating their investigatory sampling and inspection efforts through

the five sub-basins beginning with Lake Quinsigamond in 1999, Indian Lake/Mill Brook subbasin in 2000, Kettle/Tatnuck Brook subbasin in 2001, Beaver Brook subbasin in 2002, and the Blackstone/Middle River subbasin in 2003. Additionally, DPW responds to complaints and/or known hotspots as needed (CDM 1999). Wet weather sampling and monitoring in the Lake Quinsigamond subbasin was hampered in 1999 for two reasons: the timing of the Sampling and Monitoring Plan approval and the extremely dry conditions.

***OTHER:***

Hazardous Waste Sites (Ollila 2000):

Wyman-Gordon Company, Grafton (#2-0000535) is a Tier 1A waste site in the Quinsigamond River subwatershed. A preliminary assessment (1997) of sediment in Bonny Brook and Flint Pond by GZA GeoEnvironmental indicated areas where polycyclic aromatic hydrocarbons (PAHs) and metal concentrations exceeded screening levels. Additionally, areas were identified where sediments were saturated with petroleum products. A Stage II Environmental Risk Characterization is in progress. This work includes additional surface and sediment quality sampling, in-situ toxicity tests, leaching tests for wet and dry sediments, and an evaluation of potential sediment transport to the Quinsigamond River. Surface and groundwater along the eastern part of the site discharges to East Brook, another tributary of the Quinsigamond River. Wyman-Gordon sampled soils, sediment, surface water, and groundwater in this area during the summer/fall of 1999. Petroleum stained soils were also identified in a wetland area. Sampling results from these investigations will be available in 2001.

**USE ASSESSMENT**

***AQUATIC LIFE***

Biology

A preliminary baseline ecological and human health risk characterization was conducted at Fisherville Pond by McLaren/Hart Environmental Corp on behalf of the US ACOE in 1996 (US ACOE 1997). This study included both fish community and quantitative benthic invertebrate surveys. This fish survey indicated a moderately diverse and abundant community in Fisherville Pond although the community was dominated by pollution tolerant species (white sucker, golden shiner and carp). Aquatic earthworms, chironomid midges, damselflies, snails and amphipods dominated the benthic macroinvertebrate community.

The ACOE study indicated that while degradation was not severe, the impacts to the biological communities were likely the result of a combination of water and sediment quality and a less than stable pool height (US ACOE 1997).

Toxicity

*Effluent*

Wyman-Gordon Company conducted a whole effluent toxicity test on outfall 001 in May 1998. No acute toxicity was detected by *C. dubia* ($LC_{50}$ >100% effluent). Results of whole effluent toxicity monitoring of Outfall 008 in May 1998 and June 1999 were $LC_{50}$ = 70.7 and >100% effluent, respectively.

Chemistry – sediment

A preliminary baseline ecological and human health risk characterization was conducted at Fisherville Pond by McLaren/Hart Environmental Corp on behalf of the US ACOE (US ACOE 1997). This study included AVS/SEM analyses at two stations in this segment of the Quinsigamond River. All samples had SEM/AVS ratios greater than one, indicating the divalent metal concentrations in these sediments may be toxic to sediment biota.

The information available for the Quinsigamond River was limited to Flint and Fisherville ponds. The *Aquatic Life Use* for the river is on "Alert Status" due to the presence of hazardous waste contamination and likely sediment quality degradation.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

The City of Worcester DPW Storm Water Management Program, Illicit Connections Program identified 16 illicit sewer connections discharging to Lake Quinsigamond, ten of which were repaired between April 1999 and 2000 (City of Worcester DPW 2001 and Beaudoin 2001).

Although no instream fecal coliform bacteria data was available, the presence of illicit sewer connections discharging into Lake Quinsigamond is of concern and serves to place this segment on "Alert Status" for both the *Primary* and *Secondary Contact Recreational* uses.

Quinsigamond River (MA51-09) Use Summary Table

| Aquatic Life* | Fish Consumption | Primary Contact* | Secondary Contact* | Aesthetics |
|---|---|---|---|---|
|  |  |  |  |  |
| Not Assessed | | | | |

* "Alert Status" issues identified

**RECOMMENDATIONS QUINSIGAMOND RIVER (MA51-09)**

- Continue to monitor fecal coliform bacteria levels to evaluate the effectiveness of the City of Worcester DPW Storm Water Management Program, Illicit Connections Program repair projects. Review the City of Worcester's investigatory sampling and inspection data (fecal coliform bacteria) collected in this subwatershed as required in their storm water permit (MAS010002).

- Evaluate the data, when available, from the Environmental Risk Assessment of the Wyman Gordon, Grafton hazardous waste site.

- Continue to support the US ACOE Aquatic Habitat Restoration Study ongoing on the Blackstone River from Fisherville Pond to the Rhode Island border and evaluate the data/analyses as they become available.

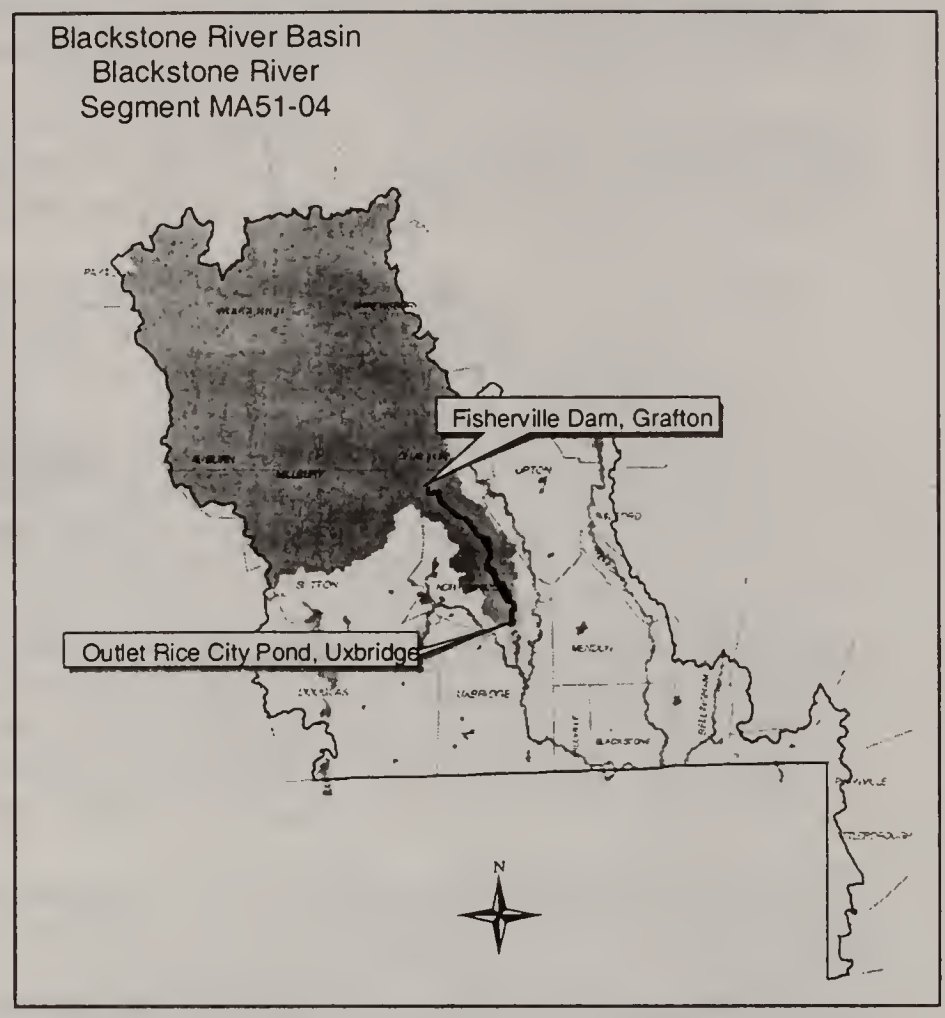
- In the next revision of the Massachusetts Surface Water Quality Standards, consider (in consultation with DFWELE) designating Axtell Brook, a tributary to the Quinsigamond River, as a cold water fishery.

- Working with MHD, evaluate opportunities to reduce pollutants from road runoff into the Quinsigamond River from State highways (e.g., Routes 9 and 20) as part of implementing Phase II of the NPDES Storm Water Program.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## BLACKSTONE RIVER (SEGMENT MA51-04)

Location: Fisherville Dam, Grafton to outlet Rice City Pond, Uxbridge.
Segment Length: 8.7 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 47% |
| Residential | 25% |
| Open Land | 8% |

The use assessment of Rice City Pond is provided in the Lakes Assessment section of this report (Table 5).

Rice City Pond was created in the 1860's to provide power, via a portion of the former Blackstone Canal, to the Central Woolen Mill in Uxbridge (which became the Stanley Woolen Mill). The original 14-foot high dam, which impounded an area of approximately 96 acres, was breached in 1955 with the intense flooding associated with Hurricane Diane (19 August 1955). The dam was replaced with a 9-foot high dam, which now impounds approximately 20 acres. Rice City Pond historically received contaminants from upstream sources. The contaminated sediments, through resuspension, continue to impact the pond.

Fish population surveys in the Blackstone River were conducted by DFWELE in July/August 1973 (Project No. F-36-R-6) (DFWELE undated).

***WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Riverdale Mills Corporation | | 9P21221602 | | | 0.3 MGD | No data supplied |
| South Grafton Water District | 2110001 | | 21211002 | Ferry Street P.S. Providence Road P.S. | 0.2 MGD | 0.21 MGD* |
| Coz Realty Trust | | | 21221602 | Railroad Street Well #2 | 0.32 MGD | 0.27 MGD |

*Withdrawal did not exceed registration amount by more than 0.1 MGD (WMA threshold)

***NPDES WASTEWATER DISCHARGE SUMMARY:***

The Grafton WWTP (MA0101311) is permitted (September 1999) to discharge 2.4 MGD of treated wastewater via outfall #001A of to this segment of the Blackstone River. The permit limit for whole effluent toxicity is $LC_{50} \geq 100\%$. Grafton is required to meet a monthly average TRC limit of 0.21mg/L, which was met during all tests from January 1996 to February 2000. Ammonia nitrogen concentrations of the effluent ranged between 1.2 and 19 mg/L based on data for the effluent from the TOXTD database. The facility appealed the limits for total phosphorus and summer total suspended solids as well as the dilution factor used to develop their total ammonia, whole effluent toxicity testing (chronic) and TRC limits.

COZ Plastics, Inc. (MA0032549) is permitted (September 1995) to discharge contact cooling water, non-contact cooling water and vacuum pump seal water via outfall #001 to this segment of the Blackstone River. The permit limit for whole effluent toxicity is $LC_{50} \geq 50\%$ (test required annually).

Riverdale Mills Corporation (MAG250279) is authorized to discharge non-contact cooling water to the Blackstone River. They were required to report the result of a modified acute and chronic toxicity test.

The Northbridge WWTP (MA0100722) is permitted (September 1999) to discharge 2.0 MGD of treated wastewater via outfall #001A to a small unnamed tributary to this segment of the Blackstone River. The permit limit for whole effluent toxicity is $LC_{50} \geq 100\%$ and a CNOEC $\geq 88\%$. Northbridge is required to meet a monthly average TRC limit of 0.013 mg/L. The facility occasionally has violations for BOD, TSS, and flow and is also under order to upgrade for nitrogen and phosphorus removal (Mounce 2000). Ammonia-nitrogen concentration data for the effluent from the TOXTD database ranged between 8.3 and 20 mg/L.

***OTHER:***
The Farnumsville hydropower facility is located between Fisherville Dam and the Riverdale impoundment. In the Blackstone River Initiative, this facility was identified as a major source of flow fluctuations in the Blackstone River. However, the hydropower facility has been off-line since 1996, and the dam is now breached and in severe disrepair (Beaudoin 2001).

FERC:
Riverdale Mills is a 150 kilowatt licensed hydropower facility (FERC Project # 9100) in the village of Riverdale, Northbridge on the Blackstone River. The 30-year permit was issued 15 June 1987 to operate as run-of-the-river. Currently one of the three tunnels with turbines is active, and the remaining two are being reconstructed. At present there are no fish passageways, however FERC may require them in the future.

In the report of a study conducted from 1994-1995, the Farnumsville Mill and Riverdale Mill hydropower facilities were identified as the primary sources of erosion of contaminated bank sediments, as well as chronic downstream transport of these contaminants (Snook 1996). The Farnumsville Mill hydropower plant has been off-line since 1996, when the town of Grafton requested that the impoundment be lowered to allow maintenance of bridge and roadways, resulting in an approximately 4-acre loss in impounded surface area. In a recent decision by the Federal Energy Regulatory Commission (FERC), it was ruled that the Blackstone River is navigable (earlier rulings deemed that the river was non-navigable), and thus subject to FERC jurisdiction when and if the facility is returned to operational condition (Beaudoin 2001).

The Riverdale Pond was largely dewatered in 1976, when the milldam was breached. In 1984, the dam was rebulit to its original height, and Riverdale Pond was again flooded. Riverdale Power & Electric Co., Inc. was established in 1985, and is currently licensed by FERC to generate power under run-of-river operation conditions. Recent studies by the USGS (1999) and Pelto confirm that the Riverdale facility backwaters the Blackstone River for a distance upstream of the USGS flow gaging station in the village of Rockdale (Northbridge), and that impacts from the facility are measured as far downstream as Rice City Pond (Northbridge/Uxbridge) (Pelto 30 March 2001).

Hazardous Waste Sites (Ollila 2000):
Waste Site #2-0000206 Kaltsas/Omni Durlite, 120 Main St. Grafton. The site also known as "Fisherville Mill" and is located on the western side of the Blackstone River below the Fisherville Dam. The site is owned by the Central Massachusetts Economic Development Authority (CMEDA). The mill was closed in 1986 and destroyed by fire in August 1999. The DEP BWSC, EPA and CMEDA removed asbestos contaminated debris and lead contaminated ash after the fire.

Number 6 oil released from former underground storage tanks is present in soils on the western side of the site near the Blackstone River Canal. The Canal extends from Fisherville Pond at the northern edge of the site to the Blackstone River at the southern boundary of the site and was formerly used to generate power at Fisherville Mill. The BWSC maintains booms to capture and control No. 6 oil that continues to discharge to the Canal. The volume of water flowing through the Canal has decreased significantly since June and July of 1999 when water levels dropped in Fisherville Pond.

A chlorinated volatile compound (CVOC) plume extends from the former mill area to the Blackstone River and Canal and CVOCs are discharging to both (concentrations below surface water quality criteria). The

CMEDA and EPA are conducting a pilot project to determine if *in-situ* bioremediation of the chlorinated hydrocarbons will be an effective remediation strategy.

PCB at concentrations between 1 and 23 ppm have been detected in river and canal sediments near the former mill. However, an on-site source of PCB has not been identified. The highest PCB concentrations were measured in samples collected near the Fisherville Dam and in the Canal south of Main Street (Route 122A).

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

The Blackstone River near Sutton Street, Northbridge (Station BLK07) received the lowest habitat score of any DWM biomonitoring station during the 1998 survey. Sediment deposition, severe channelization, and reduced riparian zone width all affected the habitat score most negatively (Appendix C, Table A5).

Gate changes at the Riverdale Mills dam have a direct and immediate effect on river stages both upstream and downstream of the dam (Socolow 1999). The raising and lowering of the pool created by the dam at Riverdale Mills has been identified as affecting streamflow conditions in the Blackstone River. The daily fluctuations of the Blackstone River due to the Farnumsville hydropower facility were significant (Wright *et al* 1996), but as the hydropower dam has been breached, flow fluctuations from this source ceased in 1996 (Beaudoin 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on this segment of the Blackstone River (Appendix C): BLK07 upstream from Sutton Street, Northbridge. The benthic assemblage at BLK07 was 29% comparable ("moderately impaired") to the regional reference station BLK09-8A.

DWM periphyton samples were collected in this segment of the Blackstone River at the benthic macroinvertebrate sampling locations. Instream vegetation was abundant, consisting of dense beds of rooted submergents (*Sagitaria subulata)* and the streaming green alga *Ulothrix zonata* (Appendix C).

Toxicity

*Ambient*

As required in their NPDES permit, COZ Plastics Inc. collects water from the Blackstone River upstream from their facility, adjacent to Main Street, Northbridge for toxicity testing. Survival (48-hour) of *C. dubia* and *P. promelas* exposed to the Blackstone River was 100% for both tests (June 1997 and July 1998).

Riverdale Mills Corporation collected water from the Blackstone River from Riverdale Pond (just upstream of Riverdale Street, Northbridge). Survival of *C. dubia* exposed to the Blackstone River was 100% for both tests (January 1996 test 48-hour exposure and February 1999 test 7-day exposure).

*Effluent*

Grafton WWTP has conducted whole effluent toxicity tests on a quarterly basis from January 1996 to February 2000. The Grafton WWTP effluent was acutely toxicity to *C. dubia* in only one ($LC_{50}$ = 17%) of 14 test events.

COZ Plastics Inc. conducted two whole effluent toxicity tests in June 1997 and July 1998 on two test organisms (*C. dubia* and *P. promelas*). No acute whole effluent toxicity was detected.

Riverdale Mills Corporation has conducted two whole effluent toxicity tests using *C. dubia* in January 1996 and February 1999. No acute toxicity was detected ($LC_{50}$ >100% effluent). No chronic toxicity was detected in the January 1996 test although the CNOEC result for the February 1999 test was 50% effluent.

Northbridge WWTP has conducted whole effluent toxicity tests on a quarterly basis from May 1996 to February 2000. The permit requires toxicity testing for two test organisms (*C. dubia* and *P. promelas*). Acute toxicity in the 16 test events was detected only once by each test organism in November 1996 and February 1997 ($LC_{50}$ = 67% for both); all other $LC_{50}$ results were >100% effluent. Chronic toxicity was detected in four of the *C. dubia* tests (CNOEC = 50% effluent) and in three of the *P. promelas* tests (CNOEC < 6.25% in May 1996 and CNOEC = 50% effluent in November 1996 and August 1999).

Chemistry – water

COZ Plastics, Inc. collected ambient river water upstream from their facility, adjacent to Main Street, Northbridge for use as dilution water in their whole effluent toxicity tests. Tests (for pH, suspended solids, ammonia nitrogen, TRC, and hardness) were conducted on 25 June 1997 and 30 July 1998. DWM physico-chemical water quality sampling was conducted on only one occasion at station BLK07-A (Sutton Street Bridge, Northbridge) on this segment of the Blackstone River (Appendix B, Figure B1). While the total phosphorus concentration was elevated (0.34 mg/L), no other variables indicated obvious water quality problems (Appendix B, Tables B5 and B6). COZ Plastics, Inc. ambient river data are summarized below (TOXTD database):

*pH*

The pH measurements were 7.2 and 7.6 SU.

*Total Residual Chlorine*

TRC concentrations were 0.05 and 0.11mg/L.

*Hardness*

Hardness measurements were 60 and 66 mg/L.

*Suspended Solids*

Suspended solid concentrations were BDL and 7.8 mg/L.

*Ammonia-Nitrogen*

$NH_3$-N concentrations were 0.15 and 0.32 mg/L.

Chemistry – sediment

As part of the Blackstone Initiative, sediment quality analyses were conducted at Farnumsville Pond, the former Rockdale Impoundment (near COZ Chemical), Riverdale Mill Pond, and Rice City Pond in 1991 and 1993. Additional work in the Blackstone River was conducted by USGS in 1993 at the former Rockdale Impoundment (near COZ Chemical) and in Rice City Pond, its floodplain, and canal area as part of a 319 project (US ACOE 1997). Elevated levels of metals were documented in the above impoundments. Sediment sampling conducted as part of the Rice City Pond Section 319 Project documented PCBs in the former Rockdale Impoundment, the Omni Duralite facility and adjacent Blackstone Canal and Rice City Pond (Snook 1996). PCBs were not detected in the sample from the Fisherville Impoundment. A sediment layer saturated with oily residues was also documented in the Rice City Pond area (Snook 1996). A subsurface oil layer similar to that found in Rice City Pond/area was also observed in the former Rockdale Impoundment, the Omni Duralite facility and adjacent Blackstone Canal. It has also been documented that the sediments accumulated behind the Farnumsville Dam emit distinct oil sheens and heavy petroleum odors when disturbed (Beaudoin 2001).

[Note: A pilot project has recently been initiated using phytoremediation technologies to stabilize and decontaminate Rice City Pond sediments (Lanza and Xing 1999). This project is funded by DEM through the Massachusetts Watershed Initiative.]

Based on a moderately impaired benthic community, habitat degradation (erosion, sedimentation and channelization), evidence of organic enrichment, hydromodification and sediment contamination, this segment of the Blackstone River in assessed as non-support for the *Aquatic Life Use*.

***FISH CONSUMPTION***

DPH has issued a fish consumption advisory due to PCB contamination for Riverdale and Rice City ponds.

Riverdale Pond, Northbridge:

1. "Children under 12, pregnant women and nursing mothers should not consume fish from Riverdale Pond in order to prevent exposure of developing fetuses and young children to PCBs."
2. "The general public should limit consumption of all fish species from Riverdale Pond to two meals per month."

Rice City Pond, Uxbridge/Northbridge:

1. "Children under 12, pregnant women and nursing mothers should not consume any fish from Rice City Pond in order to prevent exposure of developing fetuses and young children to PCBs."
2. "The general public should not consume any carp from Rice City Pond."

Based on the DPH fish consumption advisories, the *Fish Consumption Use* is non-support for the combined length of Rice City and Riverdale ponds (4.0 miles).

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

In July 1998 DWM collected a fecal coliform bacteria sample at the same location as the water quality data (Appendix B, Figure B1). The fecal coliform bacteria count was 1,020 cfu/100mLs (dry weather sampling conditions) (Appendix B, Table B7).

The Blackstone River Initiative studies included intensive sampling of bacteria under both wet and dry weather conditions. High bacteria counts were recorded during storm events throughout the mainstem Blackstone River (MA DEP and EPA 1997 and Wright *et al.* 1998). The source of this contamination is mainly from the City of Worcester CSO facility and urban runoff.

Limited data was available to assess the recreational uses. However, based on historically high bacteria counts (noted in the Blackstone River Initiative) resulting from the City of Worcester CSO, and the aesthetic quality degradation (turbidity and odors), it is best professional judgement that the *Primary* and *Secondary Contact Recreational* uses are assessed as non-support.

***AESTHETICS***

Instream turbidity (visual observations) and sewage odors were noted during the 1998 DWM biosurvey (Appendix C).

Based on the above information (turbidity and odors) and best professional judgement, the *Aesthetics Use* is assessed as non-support.

Blackstone River (MA51-04) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Flow alteration, metals, organic enrichment | | Hydromodification, contaminated sediments, municipal point sources | |
| Fish Consumption |  | NON-SUPPORT 4.0 miles Rice City and Riverdale ponds NOT ASSESSED 4.7 miles | PCB | | Unknown | |
| Primary Contact |  | NON-SUPPORT | Pathogens, turbidity | | Municipal point sources, CSO, urban runoff | |
| Secondary Contact |  | NON-SUPPORT | Pathogens, turbidity | | Municipal point sources, CSO, urban runoff | |
| Aesthetics |  | NON-SUPPORT | Odors, turbidity | | Municipal point sources, CSO, urban runoff | |

**RECOMMENDATIONS BLACKSTONE RIVER (MA51-04)**

- The Grafton WWTP (MA0101311) should collect water from the Blackstone River upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 90% at 48-hours), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of the Blackstone River. If toxicity test results do not meet permit limits (frequency and severity of violations considered), a toxicity identification and reduction evaluation and/or an instream biological monitoring evaluation may be warranted/required.

- The Northbridge WWTP (MA0100722) should also be collecting water from the small tributary upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 80% at 7 days), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of the small unnamed tributary. If toxicity test results do not meet permit limits (frequency and severity of violations considered), a toxicity identification and reduction evaluation and/or an instream biological monitoring evaluation may be warranted/required.

- Riverdale Mills is being required to install flow-measuring devices at their facility by FERC. To the extent possible, the effects of storm water runoff (particularly from the city of Worcester) and this hydropower operation should be minimized to reduce hydromodification and maintain natural flow regimes in this segment of the Blackstone River. These efforts should also help to reduce the resuspension of contaminated sediments, erosion and bank slumping.

- At present there are no fish passageways at Riverdale Mills on the Blackstone River. Work with FERC to determine if fish passageways should be required in the future.

- Evaluate the results of the Central Massachusetts Economic Development Authority and EPA pilot project to determine if *in-situ* bioremediation of the chlorinated hydrocarbons will be an effective remediation strategy data from the Kaltsas/Omni Durlite (also known as "Fisherville Mill") hazardous waste site #2-0000206.

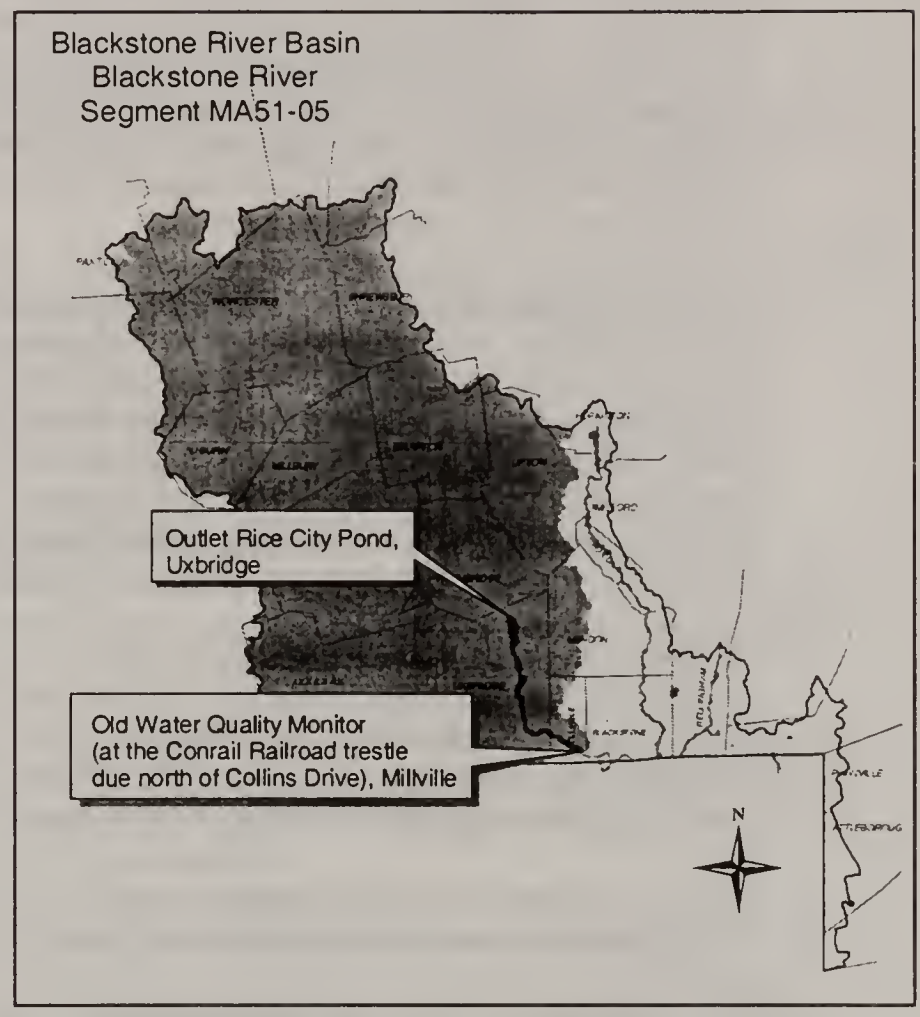
- Evaluate the effectiveness of UMASS's pilot project in stabilizing and reducing contamination in Rice City Pond (Lanza and Xing 1999).

- Continue to support the US ACOE Aquatic Habitat Restoration Study ongoing on the Blackstone River from Fisherville Pond to the RI border and evaluate the data/analyses as they become available.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## BLACKSTONE RIVER (SEGMENT MA51-05)

Location: Outlet Rice City Pond, Uxbridge to the old Water Quality Monitor (at the Conrail Railroad trestle due north of Collins Drive), Millville.
Segment Length: 7.4 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 56% |
| Residential | 20% |
| Agriculture | 7% |

The use assessment of Rice City Pond is provided in the Lakes Assessment section of this report (Table 5).

Fish population surveys in the Blackstone River were conducted by DFWELE in July/August 1973 (Project No. F-36-R-6) (DFWELE undated). Additionally, Emerson and Happy Hollow brooks in Upton, and Scadden Brook in Uxbridge, tributaries to this segment of the Blackstone River, were identified by DFWELE as supporting native brook trout based on surveys conducted in 1981, 1991, and 1992, respectively (McLaughlin 2001).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Uxbridge Water Department | 2304000 | 9P21230401 | 21230401 | 2304000-05G<br>2304000-04G | 1.24 MGD* | 0.81 MGD* |

* Indicates system-wide withdrawal

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Uxbridge WWTF (MA0102440) is authorized to discharge 2.5 MGD of treated wastewater via outfall #001 to this segment of the Blackstone River. The permit limit for whole effluent toxicity is $LC_{50} \geq 100\%$. The facility has met the average monthly TRC limit of 0.24 mg/L. The concentration of $NH_3$-N in the effluent (toxicity report information) ranged between 0.18 and 6.9 mg/L. The actual discharge from the plant is around 1 MGD. Millville Center, an area with numerous failing septic systems, is evaluating the potential for tying into the Uxbridge WWTP (Mounce 2000).

### USE ASSESSMENT

### *AQUATIC LIFE*

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on this segment of the Blackstone River (Appendix C): BLK12A upstream from Central Street, Millville, MA. The benthic assemblage at BLK12A was 24% comparable ("moderately impaired") to the Mumford River reference station BLK09-8A.

BLK12A received the highest habitat evaluation of any of the DWM sampled mainstem Blackstone River stations.

Toxicity

*Effluent*

Acute toxicity was detected in three of the ten *C. dubia* tests ($LC_{50}$ = 33 in April 1996 and 70.7% effluent in October 1997 and April 1999) conducted between April 1996 and April 2000 on the Uxbridge WWTF effluent.

Chemistry – water

DWM physico-chemical water quality sampling was conducted on only one occasion at station BLK12A (upstream from Central Street, Millville, MA) on this segment of the Blackstone River (Appendix B, Figure B1). While nutrient concentrations were slightly elevated (0.23 mg/L), none of the other variables indicated obvious problems (Appendix B, Tables B5 and B6). Water quality data for the Blackstone River at the USGS Millville gage is reported in the USGS Water Year Reports and is summarized below (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000).

*DO*

DO measurements ranged from 5.6 to 13.6 mg/L and saturation ranged from 64 to 98%. It should be noted, however, that the data do not represent worse-case (pre-dawn) conditions.

*Temperature*

The maximum temperature was 24ºC.

*pH and Alkalinity*

pH measurements ranged from 6.0 to 7.6 SU with six of 35 measurements below 6.5 SU. The alkalinity ranged from 13 to 38 mg/L.

*Turbidity*

The maximum turbidity measurement was 4.2 NTU.

*Total Phosphorus*

TP concentrations ranged between 0.04 and 0.39 mg/L.

*Hardness*

Hardness data ranged between 32 and 61 mg/L.

Chemistry – sediment

As part of the Blackstone Initiative, sediment quality analyses were conducted in the impoundments upstream of this segment of the Blackstone River. Elevated levels of metals were documented in these upstream impoundments. Additionally, a sediment layer saturated with oily residues was documented in the Rice City Pond area (US ACOE 1997). Because of the upstream hydropower facilities, storm events, and spring runoff, contaminated sediments are re-suspended and ultimately transported downstream (Snook 1996).

In September 1999 USGS sampled sediment from the Blackstone River at their gage in Millville for total PCB and organics. The concentration of total PCB was 63µg/kg and the concentration of total DDT was 2.0µg/kg (Socolow *et al.* 2000).

There are indications that water quality conditions are improving (presence of mayflies), although elevated phosphorous concentrations were documented. Rice City Pond has also been identified as the single most significant source of nonpoint source pollution (heavy metals, nutrients, and suspended solids) in the Blackstone River Basin during both wet and dry conditions (Snook 1996). Combined with the moderately impaired benthic macroinvertebrate community in the river near Central Street in Millville, the *Aquatic Life Use* is assessed as non-support for this entire segment of the Blackstone River.

***FISH CONSUMPTION***

It should be noted that DPH has issued a fish consumption advisory due to PCB contamination for two impoundments upstream of this segment (Riverdale and Rice City ponds) and an impoundment downstream of this segment (Blackstone River impoundment above the Blackstone Gorge).

Since there is no specific advisory (statewide advisory not withstanding) for this segment of the Blackstone River, the *Fish Consumption Use* is not assessed.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

Fecal coliform bacteria data for the Blackstone River at the USGS Millville gage is reported in the USGS Water Year Reports and is summarized below (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000). Between 1994 and 1999 a total of 29 fecal coliform bacteria samples were analyzed with counts ranging from 26 to 7,800 cfu/100mLs. During the primary contact recreation season (April 1 to October 15$^{th}$) only one of 15 counts (6%) exceeded 400 cfu/100 mLs. In the entire data set (secondary contact recreation season) four of 29 counts (13%) exceeded 2,000 cfu/100mLs and two counts exceeded 4,000 cfu/100mLs.

The Blackstone River Initiative studies included intensive sampling of bacteria under both wet and dry weather conditions. High bacteria counts were recorded during storm events throughout the mainstem Blackstone River (MA DEP and EPA 1997 and Wright *et al.* 1998).

Based in part on the frequency of elevated fecal coliform bacteria counts from the Blackstone River Initiative and USGS datasets, the aesthetic quality (described below), and best professional judgement, the *Primary Contact* and *Secondary Contact Recreation* uses are assessed as partial support.

***AESTHETICS***

During the Blackstone Expedition canoe trip from Worcester to Providence (20-23 September 2000) this segment of the river, although turbid from a recent heavy rainstorm, was free of objectionable odors, oil sheens, and trash. Elevated suspended solids in this segment of the river had been documented during prior surveys (Snook 1996), however turbidity levels reported by USGS at their gage downstream from both the Mumford and West rivers in Millville were low (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000). In 1998, DWM biologists noted the presence of sewage odors near Central Street in Millville. Although this segment of the Blackstone River is noted as having slightly better aesthetic qualities than the upstream segments, the water column still appears turbid as evident at the river's confluence with the West River in east Uxbridge (Cohen 2001).

Based on the visual turbidity, and objectionable odors, the *Aesthetics Use* is assessed as partial support.

Blackstone River (MA51-05) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Nutrients, metals | | Municipal point source, contaminated sediments | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | PARTIAL SUPPORT | Pathogens, odors, turbidity | | Municipal point source, urban runoff | |
| Secondary Contact |  | PARTIAL SUPPORT | Pathogens, odors, turbidity | | Municipal point source, urban runoff | |
| Aesthetics |  | PARTIAL SUPPORT | Odors, turbidity | | Municipal point source, urban runoff | |

**RECOMMENDATIONS BLACKSTONE RIVER (MA51-05)**

- The Uxbridge WWTF (MA0102440) should collect water from the Blackstone River upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 90% at 48-hours), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of the Blackstone River. If toxicity test results do not meet permit limits (frequency and severity of violations considered), a toxicity identification and reduction evaluation and/or an instream biological monitoring evaluation may be warranted/required. Currently the center of Millville has multiple failing septic systems and is in the process of evaluating a tie-in to the Uxbridge WWTF (Mounce 2000).

- Continue to support the US ACOE Aquatic Habitat Restoration Study ongoing on the Blackstone River from Fisherville Pond to the Rhode Island border and evaluate the data/analyses as they become available.

- Evaluate the effectiveness of UMASS's pilot project in stabilizing and reducing contamination in Rice City Pond (Lanza and Xing 1999).

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

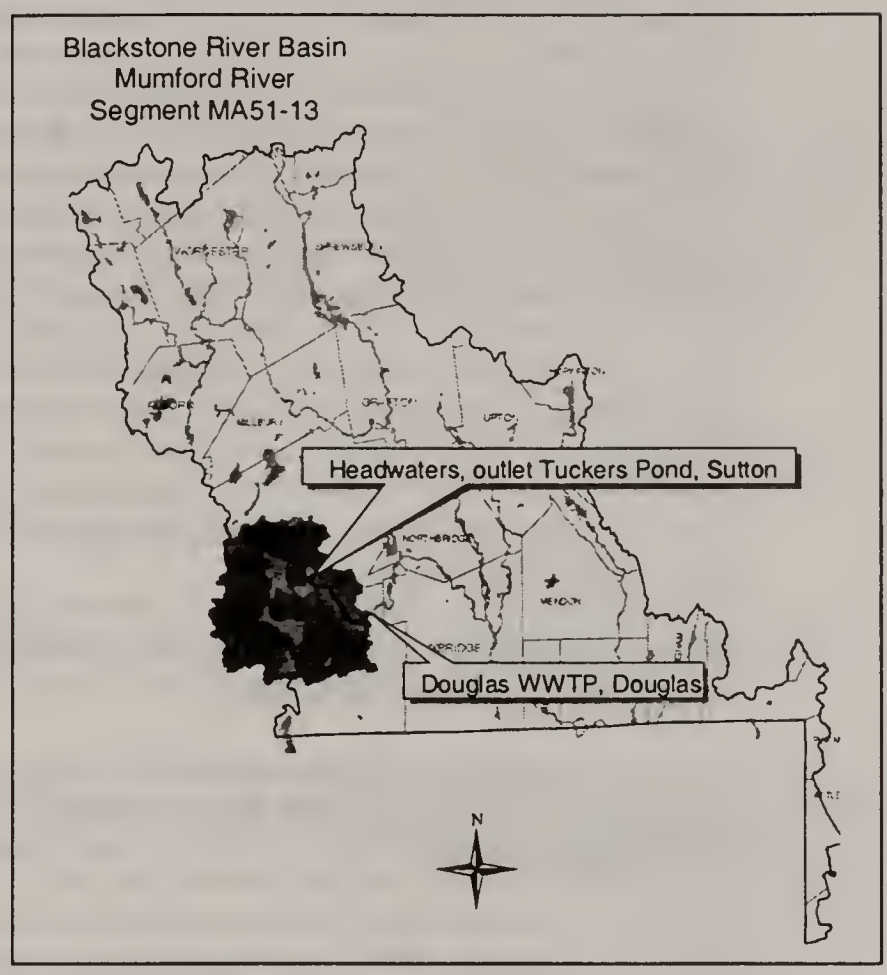
- In the next revision of the Massachusetts Surface Water Quality Standards, consider, with DFWELE, designating the following rivers in this subwatershed as cold water fisheries: Emerson, Happy Hollow, and Scadden brooks.

## MUMFORD RIVER (SEGMENT MA51-13)

Location: Headwaters, outlet Tuckers Pond, Sutton to Douglas WWTP, Douglas.
Segment Length: 5.5 miles.
Classification: Class B, Warm Water Fishery.

Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 76% |
| Residential | 8% |
| Agriculture | 8% |




The use assessment of Tuckers Pond is provided in the Lakes Assessment section of this report (Table 5).

In August 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in the upper Mumford River. Eight species of fish including, in order of dominance, fallfish, tesselated darter, brown trout, white sucker, largemouth bass, chain pickerel, and one individual each of smallmouth bass and pumpkinseed were collected (DFWELE undated).

***WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Douglas Water Department | 2077000 | 9P21207701 | 21207701 | 2077000-02G<br>2077000-01G | 0.37 MGD | 0.28 MGD |

***NPDES WASTEWATER DISCHARGE SUMMARY:***
Based on the available information, there are no regulated surface water discharges to this segment.

**USE ASSESSMENT**

***AQUATIC LIFE***

Habitat and Flow

The Mumford River (downstream from Manchaug St., Douglas) received one of the highest habitat scores in the Blackstone River watershed (Appendix C). Flow in this segment of the Mumford River is affected by the dam/reservoir operations at Manchaug Pond (Sutton/ Douglas), Whitins Reservoir (Douglas), and Stevens Pond (Sutton). HydroProjects North operates the dams at Manchaug Pond and Whitins Reservoir (Beaudoin 2001). They are authorized to release water from these waterbodies for Guilford of Maine, East Douglas facility which is located further downstream on the Mumford River (segment MA51-14). Guilford of Maine is required to maintain a low flow of 16 cfs at all times, unless conditions prohibit this flow, as a condition of their NPDES Permit (MA0001538). In addition, the town of Sutton owns the dam at Stevens Pond (Beaudoin 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on this segment of the Mumford River (Appendix C): BLK09-8A—Mumford River, downstream from Manchaug St., Douglas. By virtue of its high habitat evaluation, historically good water quality, and minimal upstream/adjacent land-use impacts this station was designated as a regional reference station for the Blackstone River Basin. As a reference station, it is considered to represent the "best attainable" (i.e., "least impacted") conditions in the watershed in terms of habitat and water quality. Biological monitoring was also conducted at one site (upstream of the Douglas WWTP) on this segment of the Mumford River

in September 1993. Results of the 1993 survey are presented in a technical memorandum entitled Mumford River Benthic Macroinvertebrate Biomonitoring: Upstream/downstream comparison of point source discharge effects (Appendix F).

DWM periphyton samples were collected in 1998 at the benthic macroinvertebrate sampling location. Aquatic mosses dominated instream vegetation, although submerged macrophytes (*Myriophyllum* sp., *Nasturtium* sp.) were observed as well. Instream algae, though minimal, consisted mainly of the green filamentous alga *Microspora* sp. (Appendix C).

DWM fish population sampling (August 1998) on the Mumford River was co-located with DWM's benthic macroinvertebrate sampling location (BLK09-8A). Eight fish species were collected, the majority of which are considered moderately tolerant to environmental perturbations (Appendix C).

Toxicity

*Ambient*

The Douglas WWTP collects water from the Mumford River upstream from their discharge (near North Street, Douglas) for use as dilution water in their whole effluent toxicity tests. Survival of *C. dubia* and *P. promelas* (48-hour exposure) was reported as being ≥ 90% for the 13 tests conducted between February 1996 and November 1999.

Guilford of Maine, Inc. East Douglas Division also collects water from the Mumford River upstream from the Douglas WWTP for use as dilution water in their whole effluent toxicity tests. Survival of *C. dubia* and *P. promelas* (7-day exposure) was reported as being ≥ 88% in all tests conducted between January 1997 and September 1999.

Chemistry – water

DWM physico-chemical water quality sampling of the Mumford River was conducted on only one occasion at station BLK09-8 (upstream of Potter Road, Douglas) (Appendix B, Figure B1). While pH, alkalinity, and hardness was slightly low (6.3 SU, 4mg/L and 7.9 mg/L, respectively), none of the other variables indicated obvious problems (Appendix B, Tables B5 and B6). The Douglas WWTP and Guilford of Maine, Inc. East Douglas Division collect Mumford River water upstream from the Douglas WWTP discharge for use as dilution water in their whole effluent toxicity tests. Results from the toxicity testing reports (TOXTD database) are summarized below.

*pH and Alkalinity*

The pH ranged between 5.8 and 8.0 SU while alkalinity ranged between 2.6 and 40mg/L.

*Total Residual Chlorine*

TRC concentrations ranged from BDL to 0.06 mg/L.

*Hardness*

Hardness measurements ranged between 8 and 36 mg/L.

*Suspended Solids*

Suspended solids measurements ranged from BLD to 33 mg/L with only one of the 27 measurements exceeding 25 mg/L.

*Ammonia-Nitrogen*

Ammonia nitrogen concentrations ranged from BLD to 0.3 mg/L.

Based on the biological (reference station, high habitat quality), toxicity testing (high survival of test organisms) and water quality data (low turbidity, etc.), the *Aquatic Life Use* is assessed as support for this segment of the Mumford River.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

DWM collected one fecal coliform bacteria sample from the Mumford River upstream of Potter Road, Douglas (BLK09-8). The fecal coliform bacteria count was <20 cfu/100mLs and was collected during dry weather conditions (Appendix B, Table B7).

Too limited instream fecal coliform bacteria data was available to assess either of the recreational uses therefore *Primary* and *Secondary Contact Recreational* uses are currently not assessed.

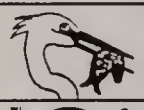
***AESTHETICS***

A shoreline survey of the Mumford River from the Manchaug residential area to Gilboa Pond Dam was conducted by the Blackstone River Watershed Association (BRWA) in May 1999. The overall appearance of the Mumford River was good with a wide variety of riparian, aquatic and wildlife habitats. A few minor problems were noted including, bank erosion, pipes discharging into river, and isolated areas of trash (Coffin 24 January 2001).

The 1998 DWM biological survey identified the aesthetics of this stream to be good (high habitat quality, low suspended solids and turbidity) with the exception of localized NPS pollution (debris, grass clippings, etc.) (Appendix C).

Based on the above information the *Aesthetics Use* is assessed as support. This use is, however, on "Alert Status" due to localized areas of erosion, and trash/debris.

Mumford River (MA51-13) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | SUPPORT | | | | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | NOT ASSESSED | | | | |
| Secondary Contact |  | NOT ASSESSED | | | | |
| Aesthetics* |  | SUPPORT | | | | |

* "Alert Status" issues identified.

**RECOMMENDATIONS MUMFORD RIVER (MA51-13)**

- Recommendations quoted from Appendix C – 1998 DEP DWM Biomonitoring Technical Memorandum.

  ... the BLK09-8A station in the Mumford River represents the "best attainable" (i.e., "least disturbed") conditions for the basin at this time. The optimum benthic community structure and balanced trophic structure observed at BLK09-8A warrant its reference station status. NPS pollution here was observed, however, and poses a threat to habitat and biological potential. Sediment deposition—possibly the result of the upstream road crossing (Manchaug Street) compromises habitat quality by reducing productive epifaunal microhabitat. A site investigation should be conducted to determine if BMPs might address sediment inputs to this portion of the river. In addition, the dumping of grass clippings, leaves, and excavated materials—presumably associated with the adjacent cemetery—occurs along the right bank of the sampling reach and should be strongly discouraged.

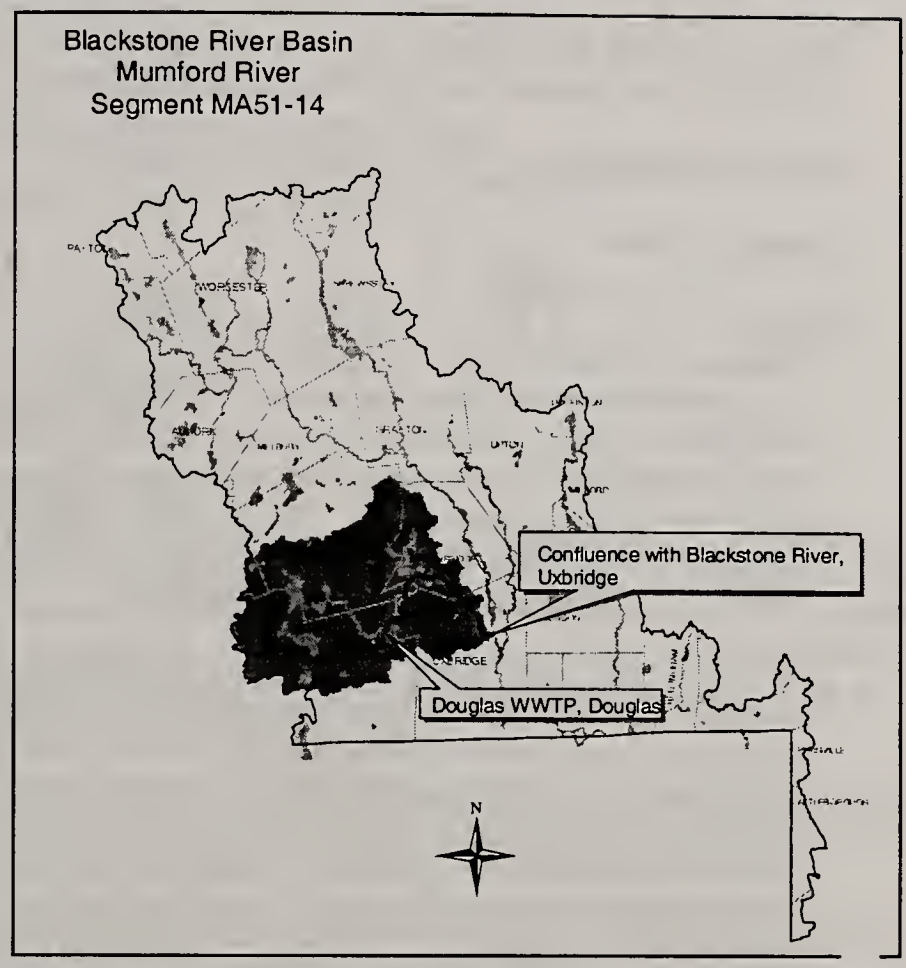
- Work with the BRWA to implement their short and long-term actions including erosion control, development of a stewardship program, and a stream cleanup.

- Evaluate reservoir operations and optimize release practices to maintain minimum flow and to the extent possible, natural flow regimes in the Mumford River.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## MUMFORD RIVER (SEGMENT MA51-14)

Location: Douglas WWTP, Douglas to confluence with Blackstone River, Uxbridge.
Segment Length: 9.0 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 69% |
| Residential | 12% |
| Agriculture | 8% |

The use assessments of Gilboa, Lackey, Meadow, Linwood, Whitin and Caprons ponds are provided in the Lakes Assessment section of this report (Tables 5 and 6).

Cold Stream Brook in Uxbridge, Cook Allen Brook in Sutton and Streamburg Brook in North Bridge, tributaries to this segment of the Mumford River, were identified by DFWELE as supporting native brook trout based on surveys conducted in 1985, 1988, and 1983, respectively (McLaughlin 2001).

A recent restoration project on the Mumford River was conducted at Lackey Pond. The Lackey Dam had deteriorated to the point that it was no longer functional, and the Lackey Pond marshes were drained. A long-term waterfowl banding study conducted from the mid-1970's to 1990 provided historical data on the importance of Lackey Pond to waterfowl and marsh birds. The restoration project was conducted from 1998 to 2000. The pond height will now be managed by DFWELE to maximize deep and shallow marsh habitat (to maintain pre-1990 conditions). The banding study resumed in 2000, and observations indicate that the marsh is recovering rapidly; wood ducks are already using Lackey Pond for a night roosting site (Heusman 2001).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (# days if < 365) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Guilford of ME Finishing Services | | 9P321207702 | | Guilford Pond | 1.5 MGD | 0.27 MGD |
| Whitinsville Water Company | 2216000 | 9P21221601 | 21221601 | Sutton Well Field Whitin Well Field | 1.43 MGD | 1.1 MGD |
| Whitinsville Golf Club | | | 21221603 | Whitinsville GC | 0.047 MGD (180 days) | 0.06 MGD* |

*Withdrawal did not exceed registration amount by more than 0.1 MGD (WMA threshold)

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Douglas WWTP (MA0101095) is permitted (September 1995) to discharge 0.18 MGD of treated wastewater via outfall #001A to the Mumford River. The permit limit for whole effluent toxicity is $LC_{50} \geq$ 100% and the TRC limit is 0.6 mg/L. The facility is in the process of facilities planning and is looking to expand to 0.7 MGD (Mounce 2000). Since 1993, the Town has been under a sewer moratorium; the Department will continue the enforcement activity and monitor their return to compliance (Kimball 2001).

Guilford of Maine, Inc. East Douglas Division (MA0001538) is permitted (December 1999) to discharge 1.25 MGD of treated wastewater via outfall #003 to this segment of the Mumford River. The facility is

required to conduct whole effluent toxicity tests six times per year, to report the $LC_{50}$, and to meet a CNOEC limit of ≥ 10.8% effluent.

[Note: Currently, storm water from the subdivision on Country Club Lane, Northbridge is discharged directly to the Linwood Impoundment (Beaudoin 2001).]

## USE ASSESSMENT

### *AQUATIC LIFE*

Biology

Biological monitoring was conducted at three sites (downstream of the Douglas WWTP and upstream and downstream of Guilford of Maine, Inc. East Douglas facility) in this segment of the Mumford River in September 1993. Results of this survey are presented in a technical memorandum entitled Mumford River Benthic Macroinvertebrate Biomonitoring: Upstream/downstream comparison of point source discharge effects (Appendix F). The benthic macroinvertebrate community downstream from the Douglas WWTP discharge was found to be severely impaired (14% comparability) as compared to the reference station upstream from the discharge.

As part of their 1993 NPDES permit requirements, Guilford of Maine, Inc. East Douglas facility conducted an instream benthic macroinvertebrate study in 1996 of the Mumford River. Artificial substrates (rock baskets) were deployed at six sites (upstream and downstream of the Douglas WWTP discharge and upstream and three downstream sites at the Guilford of Maine, Inc. East Douglas facility discharge) in July and retrieved at the end of August (Acheron, Inc. 1997). The analysis of the benthic macroinvertebrate data indicated a change in the structure and function of the community, which was attributed as a response to available food resources (i.e., algae from Gilboa Pond, and organic solids from Guilford's discharge). In June 1997 Guilford's recently completed secondary wastewater treatment plant went on-line which resulted in a significant and dramatic decrease in the quantity of organic solids discharged from their facility to the Mumford River (Goodman and Ball 1997).

Toxicity

*Effluent*

Douglas WWTP has conducted whole effluent toxicity tests on a quarterly basis from February 1996 to November 1999. The effluent was acutely toxic to *C. dubia* and *P. promelas* in three of the 13 tests ($LC_{50}$ ranging between 71 and 84% effluent).

Guilford of Maine, Inc. East Douglas Division conducted whole effluent toxicity tests on a quarterly basis between February 1996 and September 1999 on two test organisms (*C. dubia,* 17 tests and *P. promelas,* 9 tests). Acute toxicity was detected by both *C. dubia* ($LC_{50}$ = 74% effluent) and *P. promelas* ($LC_{50}$ = 49% effluent) in September 1998 as was chronic toxicity (CNOEC results ranged between < 5% and 100% effluent). The facility's NPDES permit was reissued in December 1999 and required more frequent toxicity testing.

The biological (benthic macroinvertebrate) monitoring data for this segment of the Mumford River was limited to evaluating the instream effects of the two NPDES discharge facilities. Although severe impacts to the benthic macroinvertebrate community were documented downstream from the Douglas WWTP discharge in 1993, recent inspections of the facility and their discharge monitoring reports have indicated improvements. Additionally, Guilford of Maine, Inc. East Douglas constructed a new wastewater treatment facility in 1997 (subsequent to the surveys) which has greatly improved their effluent quality.
As a result of these changes, the instream biological monitoring data is no longer representative of current conditions. Therefore the *Aquatic Life Use* for this segment of the Mumford River is not assessed, however it is considered to be on "Alert Status".

### *AESTHETICS*

A shoreline survey of the upper portion of this segment of the Mumford River between the Douglas WWTP discharge and the Gilboa Pond Dam was conducted by the Blackstone River Watershed Association (BRWA) in May 1999. Their notes indicated odor and turbidity downstream from the Douglas WWTP discharge (Coffin 24 January 2001).

Too little information is available to assess *Aesthetics Use* for this segment of the Mumford River. Objectionable conditions, however, were noted in the upper reach of this segment and therefore this use is on "Alert Status".

Mumford River (MA51-14) Use Summary Table

| Aquatic Life* | Fish Consumption | Primary Contact | Secondary Contact | Aesthetics* |
|---|---|---|---|---|
|  |  |  |  |  |
| Not Assessed | | | | |

* "Alert Status" issues identified

**RECOMMENDATIONS MUMFORD RIVER (MA51-14)**

- Reissue Douglas WWTP (MA0101095) permit with appropriate limits and monitoring requirements. The Town has been working on a wastewater facilities plan and is planning to expand although a final implementation schedule has been not yet been proposed. Since instream impacts were documented as a result of their discharge, continue to carefully monitor the facility's compliance with their permit limits. If the facility continues to have problems meeting their whole effluent toxicity testing limit, a toxicity identification and reduction evaluation should be conducted.

- Conduct a benthic macroinvertebrate survey to evaluate the current impact(s) of the Douglas WWTP and the Guilford of Maine, East Douglas discharges to this segment of the Mumford River.

- Collect water quality data (e.g., DO, pH, temperature, flow, nutrients, etc.) to evaluate the impacts of the treatment plant discharges, and impoundments along this segment of the Mumford River.

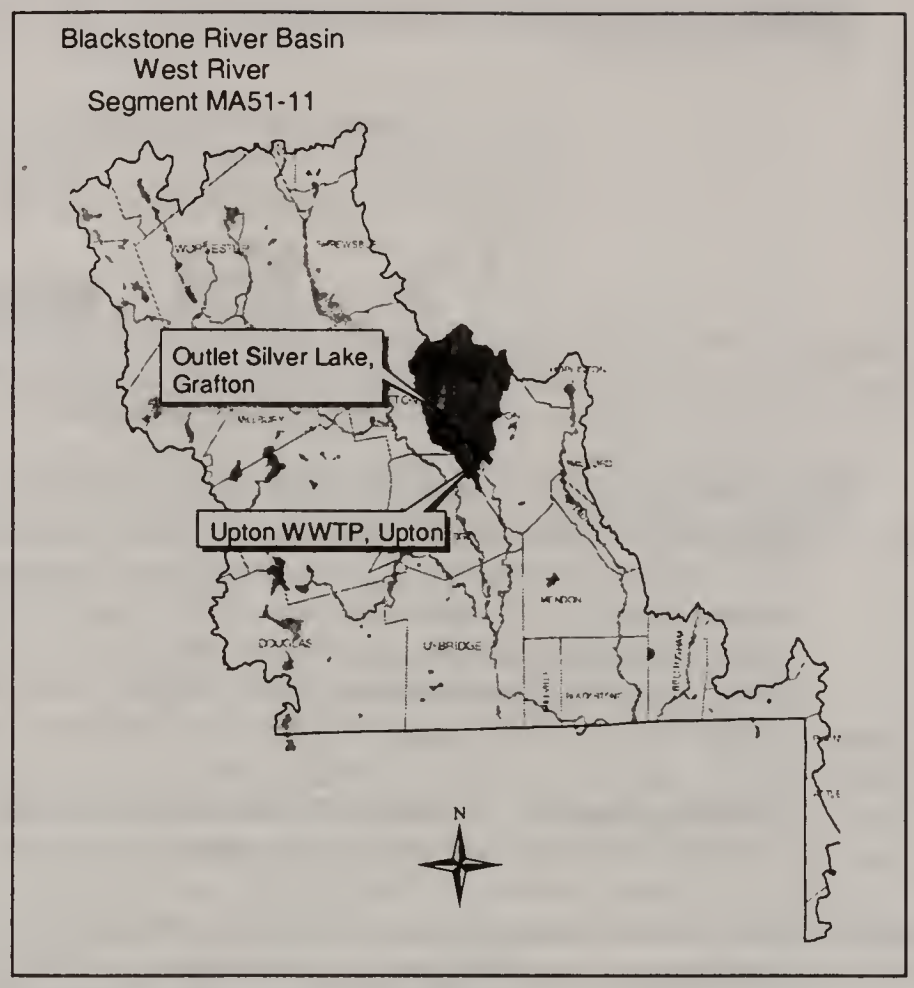
- Determine the need for a storm water permit for the subdivision on Country Club Lane, Northbridge.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- In the next revision of the Massachusetts Surface Water Quality Standards, consider with DFWELE designating the following rivers in this subwatershed as cold water fisheries: Cold Stream, Cook Allen, and Streamburg brooks.

## WEST RIVER (SEGMENT MA51-11)

Location: Outlet Silver Lake, Grafton to Upton WWTP, Upton.
Segment Length: 3.0 miles.
Classification: Class B, Cold Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 70% |
| Residential | 12% |
| Agriculture | 11% |

The use assessments of Silver Lake, Lake Wildwood, and Williams Street Pond are provided in the Lakes Assessment section of this report (Tables 5 and 6).

In July 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in the upper West River. Ten species of fish including, in order of dominance, bluegill, white sucker, redfin pickerel, three individuals each of chain pickerel, brown bullhead and yellow bullhead, and two individuals each of largemouth bass and fallfish, and an individual pumpkin seed were collected (DFWELE undated). Additionally, Miscoe Brook in Grafton and Warren Brook in Upton, tributaries to this segment of the West River, and the West River in Upton were identified by DFWELE as supporting native brook trout based on surveys conducted in 1999 and 2000, respectively (McLaughlin 2001).

The upper length of this segment, which extends from Silver Lake, Grafton to the confluence with Warren Brook, is within the Miscoe-Warren-Whitehall ACEC. In the nomination document for this ACEC, the aquatic resources included cold-water fish, including two species of swamp darter, as well as "prolific and self-sustaining native brook trout populations" (____ 1999).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Upton Department of Public Works | 2303000 | 9P421230301 | | 01G Glen Avenue Wellfield<br>02G West River St. Well | 0.48 MGD | 0.44 MGD |

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Based on the available information, there are no regulated surface water discharges to this segment of the West River.

### USE ASSESSMENT

### *AQUATIC LIFE*

Chemistry – water

DWM physico-chemical water quality sampling was conducted on only one occasion during the 1998 sampling program at station WR12 (upstream, of Glen Avenue, Upton) on this segment of the West River (Appendix B, Figure B1). None of the variables indicated obvious problems with water quality conditions (Appendix B, Tables B5 and B6). This is consistent with data collected in previous surveys including June and August 1988 (Beaudoin 2001).

Although there were no indications of water quality impairment, too little data is available to assess the status of the *Aquatic Life Use*.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

In July 1998 DWM collected a fecal coliform bacteria sample from the West River upstream, of Glen Avenue, Upton. The fecal coliform bacteria count was 2,000 cfu/100mLs and was collected during dry weather conditions (Appendix B, Table B7).

Although the fecal coliform bacteria count was elevated, the data were too limited to assess either the *Primary* or *Secondary Contact Recreational* uses. These uses although currently not assessed, are on "Alert Status".

West River (MA51-11) Use Summary Table

| Aquatic Life | Fish Consumption | Primary Contact* | Secondary Contact* | Aesthetics |
|---|---|---|---|---|
|  |  |  |  |  |
| Not Assessed | | | | |

* "Alert Status" issues identified.

**RECOMMENDATIONS WEST RIVER (MA51-11)**

- Conduct fecal coliform bacteria monitoring during both wet and dry weather conditions to evaluate the status of the recreational uses and isolate sources of contamination if necessary.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- As part of the recent "Beaches Bill" water quality testing, bacteria sampling will be required at all formal bathing beaches. Identify any formal bathing beaches along this segment, and when available, review the bacteria data to assess the status of the recreational uses.

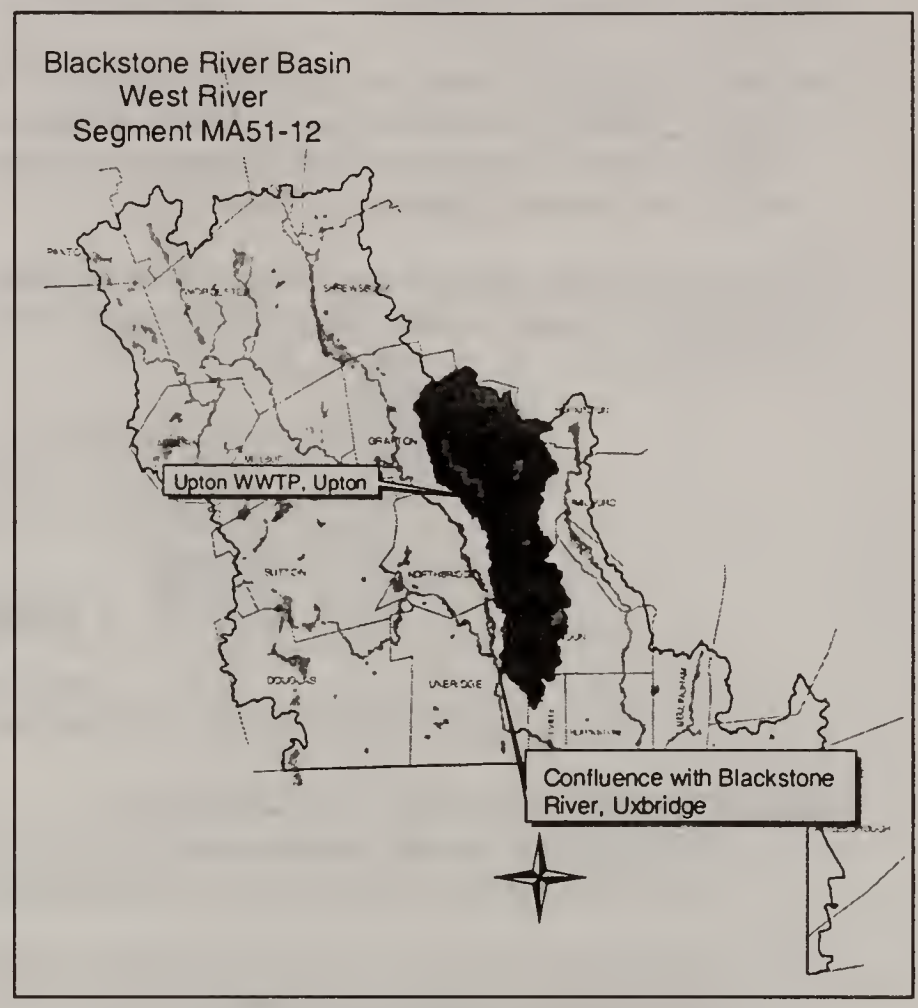
- In the next revision of the Massachusetts Surface Water Quality Standards, consider designating, with DFWELE, the following rivers in this subwatershed as cold water fisheries: Miscoe and Warren brooks.

## WEST RIVER (SEGMENT MA51-12)

Location: Upton WWTP, Upton to confluence with Blackstone River, Uxbridge.
Segment Length: 8.8 miles.
Classification: Class B, Warm Water Fishery.

Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 70% |
| Residential | 14% |
| Agriculture | 9% |




The use assessment of West River Pond is provided in the Lakes Assessment section of this report (Table 5).

DFWELE (Project No. F-36-R-6) conducted a fish population survey in the lower West River (survey not dated). Ten species of fish including, in order of dominance, tesselated darter, largemouth bass, redfin pickerel, yellow bullhead, chain pickerel, banded sunfish, white sucker, brown bullhead, bluegill, and an individual pumpkin seed were collected (DFWELE undated). Additionally, Taft Pond and Center brooks in Upton, tributaries to the West River, and the West River in Upton, were identified by DFWELE as supporting native brook trout based on surveys conducted in 1983 and 2000, respectively (McLaughlin 2001).

The ACOE North Atlantic Division (NAE) maintains a dry-bed reservoir, the West Hill Dam Flood Control Project, in the towns of Upton, Northbridge and Uxbridge within this segment of the West River. The West Hill Dam was built between 1959 and 1961 in the wake of Hurricane Diane (1955), to provide flood storage along the West and lower Blackstone rivers. The drainage area at the dam is 27.9 square miles. The 614-acre Army Corps property encompasses approximately 2.9 miles of the West River. Resources within this project include a bathing beach at Harrington Pool (a small pond upstream of the dam), fish and wildlife habitat, fishing, and well as extensive hiking trails along most of the length of the flood storage area (both east and west banks). Water quality monitoring is conducted each year by the ACOE at their bathing beach (fecal coliform bacteria sampling).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Miscoe Springs Inc.* | | | 21217902 | Well #1 | 0.06 MGD | 0.04 MGD |
| Uxbridge Water Department | 2304000 | 9P21230401 | 21230401 | 2304000-02G<br>2304000-03G<br>2304000-01G | 1.24 MGD** | 0.81 MGD |

* Non-transient, Non-community source ** Indicates system-wide withdrawal

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Upton WWTF (MA0100196) is permitted (September 1995) to discharge 0.30 MGD of treated wastewater via outfall #001A to a small unnamed tributary of the West River. The permit limits for whole effluent toxicity are $LC_{50} \geq 100\%$ and CNOEC $\geq$ 48%. Based on the data reported by Upton in their toxicity testing reports between January 1996 and May 2000, the facility has met their monthly average TRC limit of 0.023 mg/L. The effluent ammonia-nitrogen concentrations ranged between 0.06 and 16.1mg/L. The facility was upgraded in 1999 including dechlorination.

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

The West River (station WR01 - upstream from West River St., Upton) received one of the highest habitat scores in the Blackstone River watershed (Appendix C). The ACOE maintains a flood control project, West Hill Dam, on this segment of the West River. The project is operated as run-of-river with minimal/no flow manipulation, except during flood events (Beaudoin 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on this segment of the West River (Appendix C) WR01—West River, upstream from West River St., Upton. This station was 67% comparable to the Mumford River regional reference station (BLK09-8A). Although this comparability is considered "slightly impaired" several of the metrics scored as well as or better than metrics for the reference condition in the Mumford River. The benthic community at station WR01 was, however, 81% comparable to the reference station in Kettle Brook (KB10).

DWM also conducted fish population sampling (August 1998) on the West River (co-located with the DWM benthic macroinvertebrate sampling location WR01). Nine fish species were collected, the majority of which are considered moderately tolerant to environmental perturbations, which was again the highest number of species collected at any station in the Blackstone River Basin during the 1998 DWM fish surveys (Appendix C). DFWELE also stocks this segment of the West River with trout (ACOE 1996).

Toxicity

*Effluent*

Upton WWTF has conducted whole effluent toxicity tests on a quarterly basis from January 1996 to May 2000. The effluent was acutely toxicity to *C. dubia* in three ($LC_{50}$ 52.6%, 37%, and 83.8%) of 16 test events. Chronic toxicity was exhibited by *C. dubia* in six of 16 test events and was 48% (at the permit limit) in four other tests.

Chemistry – water

DWM physico-chemical water quality sampling was conducted once at stations WR10 (downstream, of Pleasant Road, Upton) and WR03 (upstream, down the bank at East Hartford Street bridge, Uxbridge) (Appendix B, Tables B5 and B6). Station WR10 is located approximately 0.4 miles downstream from the Upton WWTF in a large wetland while station WR03 is approximately five miles downstream from the discharge (Appendix B, Figure B1).

*DO*

The DO concentration in the West River less than half a mile downstream from the Upton WWTF discharge, in a large wetland, was 4.1 mg/L and saturation was 45%. Further downstream station (WB03), the DO concentration was 7.7mg/L and 85% saturation. It should be noted, however, that the data do not represent worse-case (pre-dawn) conditions.

*Temperature*

Temperature measurements at both stations were approximately 20°C.

*pH*

The pH measurements from upstream to downstream were 6.2 and 6.6 SU.

*Hardness*

The hardness measurement at WR10 was 32 mg/L and 23 mg/L at WR03.

*Suspended Solids*

Suspended solid concentrations were 1.8mg/L at WR10 and 3.8 mg/L at WR03.

*Ammonia-Nitrogen*

The ammonia nitrogen concentration was higher at WR10 (0.96 mg/L) than at WR03 (BDL).

*Phosphorus*

The concentration of total phosphorus was higher at WR10 (0.19 mg/L) than at WR03 (0.06 mg/L).

Chemistry – sediment

In October 1995 sediment samples were collected just upstream of the Harrington Pool, on the West River at the West Hill Dam project as part of the ACOE's commitment to determine the presence/absence of EPA Priority Pollutants at Army Corps projects nationwide (Barker 1999b). Analyses included dioxins, furans, volatile (VOC) and semi-volatile organic compounds (SVOC), metals, PCBs, pesticides, and Total Organic Carbon (TOC). Grain size analysis indicated that the sample consisted of mostly sand, a small portion of gravel, and very little silt. DDE, a breakdown product and an impurity in DDT, was measured in a quantity too low to be quantified, but was estimated to be 16 ppm. DDD, both an insecticide and a DDT breakdown product, was also found at a level too low to be quantified, but was estimated to be 11 ppm. Although both exceeded ER-L, ER-M and Ontario Guidelines for lowest effects levels, these were far below severe effects levels noted in the Massachusetts Contingency Plan. The conclusion is that the DDE and DDD concentrations in this area may have minor effects on sensitive local benthic populations, but is not an overall concern. Similarly, trace metals, endrin ketone, dioxins and furans were measured at extremely low or background levels, and were determined to be of no concern to human health or the environment. PCBs were not detected. Although some compounds were detected at levels that may be high enough to exert a minor influence on sensitive localized populations of benthic organisms, none were sufficiently high to interfere with the project uses. Overall priority pollutants levels were reflective of "relatively clean, natural background conditions" (Barker 1999b).

Based primarily on the benthic macroinvertebrate data that indicated slight to no impairment, the *Aquatic Life Use* is assessed as support for this segment of the West River. The *Aquatic Life Use* is however on "Alert Status" for one mile downstream of the Upton WWTF discharge due to effluent toxicity.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

In July 1998 DWM collected fecal coliform bacteria samples at stations WR10 (downstream, of Pleasant Road, Upton) and WR03 (upstream, down the bank at East Hartford Street bridge, Uxbridge) (Appendix B, Table B7). The fecal coliform bacteria counts were <100 cfu/100mLs at both stations. Samples were collected during dry weather conditions.

The ACOE collects fecal coliform bacteria samples from their bathing beach (Harrington Pool) at West Hill Dam every other week during their primary recreation season (3rd week of May – Labor Day). Between 1998 and 2000 fecal coliform bacteria counts exceeded the bathing beach standard of 200 cfu/100mLs on only three occasions. The ACOE has infrequently (3 days between 1998 and 2000) closed their bathing beach at West Hill Dam due to elevated levels of fecal coliform bacteria. These elevated counts were associated with storm events and resulted in the closure of their bathing beach (Barker 1998, 1999a, 2000).

Although the spatial coverage was limited, fecal coliform bacteria counts were usually below the primary contact recreational use guidance. Based on the low fecal coliform bacteria counts, both the *Primary* and *Secondary Contact Recreational* uses are assessed as support.

***AESTHETICS***

Although an abundance of aquatic vegetation has been noted in the West River downstream from the Upton WWTF discharge, the overall aesthetics of this stream were good with high habitat quality, low suspended solids and low visual turbidity (Appendix C, Beaudoin 2001).

Based on the high aesthetic quality the *Aesthetics Use* is assessed as support.

West River (MA51-12) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life* |  | SUPPORT | | | | |
| Fish Consumption |  | NOT ASSESSED | | | | |
| Primary Contact |  | SUPPORT | | | | |
| Secondary Contact |  | SUPPORT | | | | |
| Aesthetics |  | SUPPORT | | | | |

* "Alert Status" issues identified

**RECOMMENDATIONS WEST RIVER (MA51-12)**

- Conduct additional DO monitoring (including pre-dawn measurements) in the West River to determine if low dissolved oxygen and percent saturation conditions are frequent and prolonged. Additionally investigate if the source of the low dissolved oxygen is naturally occurring or induced by the WWTF discharge.

- Reissue the Upton WWTF (MA0100196) permit with appropriate limits and monitoring requirements. The WWTF should collect water upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 80% at 7-day), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of the receiving stream. Additionally, if the facility continues to have acute and chronic toxicity problems, they should be required to conduct a toxicity identification and reduction evaluation.

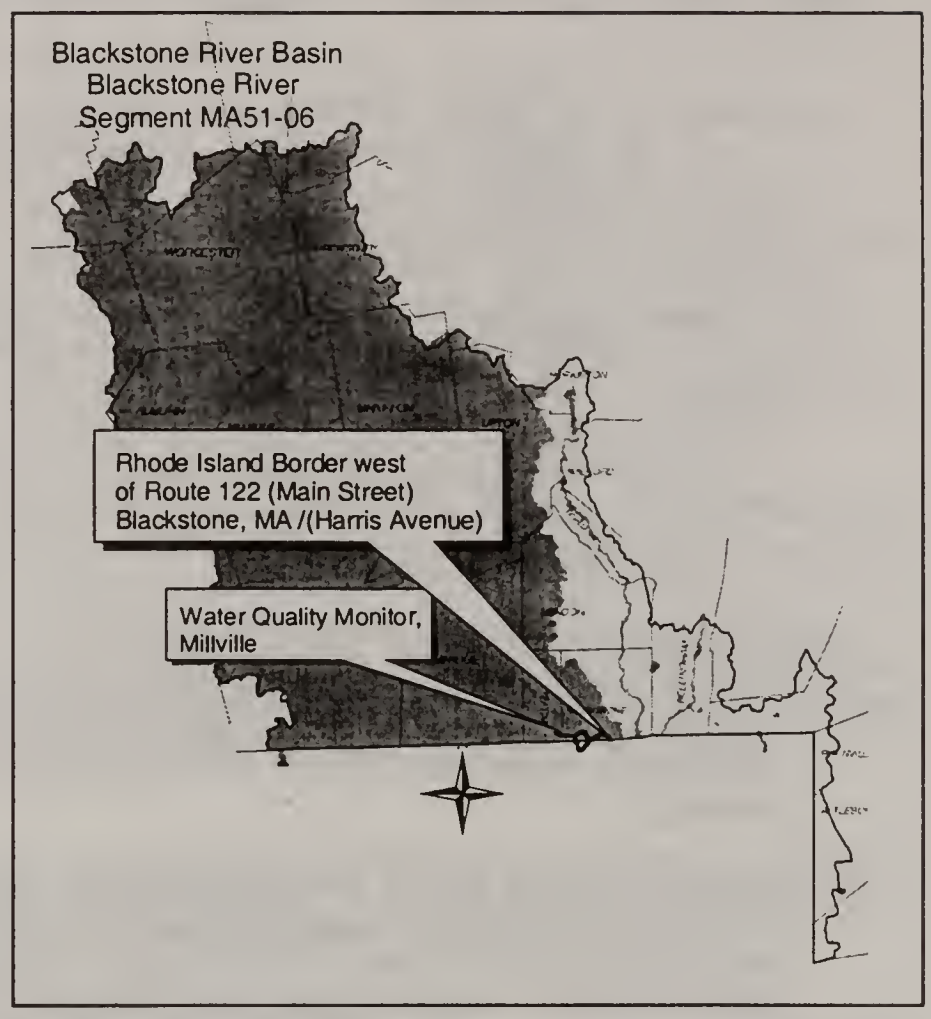
- As part of the recent "Beaches Bill" water quality testing, bacteria sampling will be required at all formal bathing beaches. Continue to review the data collected by the ACOE from their bathing beach at Harrington Pool. Identify any additional formal bathing beaches along this segment, and when available, review the bacteria data to better assess the status of the recreational uses.

- In the next revision of the Massachusetts Surface Water Quality Standards, consider with DFWELE designating the following rivers in this subwatershed as cold water fisheries: Taft Pond Brook and Center Brook.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## BLACKSTONE RIVER (SEGMENT MA51-06)

Location: From the Water Quality Monitor, Millville to the Rhode Island Border west of Route 122 (Main Street) Blackstone, MA /(Harris Avenue) North Smithfield, RI.
Segment Length: 3.7 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 58% |
| Residential | 19% |
| Agriculture | 7% |

Fox Brook in Blackstone, a tributary to this segment of the Blackstone River, was identified by DFWELE as supporting native brook trout based on a survey conducted in 1987 (McLaughlin 2001).

Downstream from Millville, the Blackstone River flows southeast and becomes impounded by the Tupperware Dam in Blackstone Massachusetts known as the Millville Pond Impoundment. The natural course of the river is south through the Blackstone Gorge, into Rhode Island. Through the Gorge the river runs wild through steep cliffs vegetated with mountain laurel and hemlock. In spots, these cliffs rise to a height of sixty feet. This stretch of the Blackstone is one of the few in Rhode Island with rapids for white water canoeing. Downstream from the Gorge, the Blackstone River is joined by the Branch River, turns northeast and flows back into Massachusetts.

There is, however, a power canal intake located above the Tupperware Dam in the Millville Pond Impoundment where water is drawn by the Synergics Hydropower project (see FERC below) through their turbines at the former Tupperware Mill. The power canal is shown above in the map insert as the upper loop in this segment of the Blackstone River. Water from the power canal flows back into the mainstem Blackstone River as it reenters Massachusetts. From this point the river flows generally east, turns southeast and again enters Rhode Island.

***WMA WATER WITHDRAWAL AND NPDES WASTEWATER DISCHARGE SUMMARY:***
There are no known regulated water withdrawals or surface water discharges in this segment of the Blackstone River.

***OTHER:***
FERC
Synergics Hydropower project is a 2,000 kilowatt licensed hydropower facility (FERC Project # 3023) in the village of Waterford, in the old Tupperware Mill facility, just over the Massachusetts state line in Rhode Island. The 30-year permit was issued by FERC on 20 October 1980 to operate as a run-of-the-river facility. Water is impounded at the 'fixed height' Tupperware Dam in Blackstone, MA. Power is generated by opening turbines at the Synergics Hydropower project in Rhode Island, which pulls water down through the "Power canal". This results in the reduction of flow through the Blackstone Gorge, the only habitat of this type in the entire length of the river. The flow is then returned to the Blackstone River at the state line. Although their license contains no by-pass flow requirement, they are presently voluntarily spilling between 11 and 20 cfs over the dam (Grader 2001).

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

The generation of power at the Synergics Project results in the lowering of the water level behind the Tupperware Dam. During power generation, little flow spills over the Tupperware dam into the Blackstone Gorge. The 1.0-mile reach of the Blackstone River downstream from the dam through the gorge to the Synergics Project tailrace (this reach of the river flows into and then back out of Rhode Island) is impacted by these practices. At times of low river flow, there are periods when no water spills over the dam, even though the hydropower facility is off-line during these periods (Beaudoin 2001). The Blackstone Stream Flow Task Force has been meeting with Synergics for the past three years and they have been fairly responsive to the flow issues. The company has shut down their hydropower operations for months during typical summer low flow periods (1999 and 2000) and have agreed to allow a minimum flow to spill over the dam into the Blackstone Gorge (Beaudoin 2001).

Biology

In June 1999, fish population sampling was conducted by DFWELE in the Blackstone River near its confluence with the Branch River (Rhode Island). A relatively diverse fish population was found including smallmouth bass (three year-classes), and fallfish, both pollution sensitive species (McLaughlin 1999).

Coupled with the flow alteration (hydromodification) along this segment of the Blackstone River, the assessment of the *Aquatic Life Use* for this segment of the Blackstone River was extrapolated from segment MA51-05 where more instream biological and physico-chemical data were available. These data were summarized as follows:

> There are indications that water quality conditions are improving, although elevated phosphorous concentrations were documented. Rice City Pond has also been identified as the single most significant source of non point source pollution (heavy metals, nutrients, and suspended solids) in the Blackstone River Basin during both wet and dry conditions (Snook 1996). Combined with the moderately impaired benthic macroinvertebrate community in the river near Central Street in Millville, the *Aquatic Life Use* is assessed as non-support for this entire segment of the Blackstone River.

Based on these data, the *Aquatic Life Use* for this segment of the Blackstone River is assessed as non-support.

### *FISH CONSUMPTION*

DPH has issued a fish consumption advisory due to PCB contamination for the Blackstone River impoundment (Millville Pond Impoundment) above the Blackstone Gorge, Blackstone as follows:

1. "Children under 12, pregnant women and nursing mothers should refrain from consuming any fish from the Blackstone River Impoundment above the Blackstone Gorge in order to prevent exposure of developing fetuses, nursing infants and young children to PCBs."
2. "The general public should refrain from consumption of carp and white suckers from the Blackstone River Impoundment above the Blackstone Gorge".

The *Fish Consumption Use* in the upper 1.0-mile reach of this segment is assessed as non-support due to a fish consumption advisory (PCB). The lower 2.7 miles are not assessed.

### *PRIMARY CONTACT AND SECONDARY CONTACT RECREATION*

Fecal coliform bacteria data for the Blackstone River at the USGS Millville gage was presented in the Blackstone River segment MA51-05. In this dataset, 6% of the samples collected during the primary contact recreation season exceeded 400 cfu/100mls while 13% of the samples collected year-round exceeded 2,000 cfu/100mLs and two counts exceeded 4,000 cfu/100mLs (Socolow *et al.* 1996, Socolow *et al.* 1997, Socolow *et al.* 1998, Socolow *et al.* 1999 and Socolow *et al.* 2000).

The Blackstone River Initiative studies included intensive sampling of bacteria under both wet and dry weather conditions. High bacteria counts were recorded during storm events throughout the mainstem Blackstone River (MA DEP and EPA 1997 and Wright *et al.* 1998).

Based in part on the frequency of elevated fecal coliform bacteria counts from the Blackstone River Initiative and USGS datasets, and best professional judgement, the *Primary Contact* and *Secondary Contact Recreation* uses are assessed as partial support.

***AESTHETICS***

Although the Blackstone Gorge is a beautiful reach within this segment of the Blackstone River, free of trash and debris, the river still is occasionally turbid and smells of sewage after storm events.

Based on visual observations of turbidity and objectionable odors, the *Aesthetics Use* is assessed as partial support.

Blackstone River (MA51-06) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life |  | NON-SUPPORT | Flow alteration, nutrients, metals | | Hydromodification, municipal point source, contaminated sediments | |
| Fish Consumption |  | NON-SUPPORT upper 1.0 miles<br>NOT ASSESSED lower 2.7 miles | PCB | | | |
| Primary Contact |  | PARTIAL SUPPORT | Pathogens, odor, turbidity | | Municipal point source, urban runoff | |
| Secondary Contact |  | PARTIAL SUPPORT | Pathogens, odor, turbidity | | Municipal point source, urban runoff | |
| Aesthetics |  | PARTIAL SUPPORT | Odors, turbidity | | Municipal point source, urban runoff | |

**RECOMMENDATIONS BLACKSTONE RIVER (MA51-06)**

- Continue to work with Synergics Hydropower to optimize operation practices to insure maintenance of flow through the Blackstone Gorge.

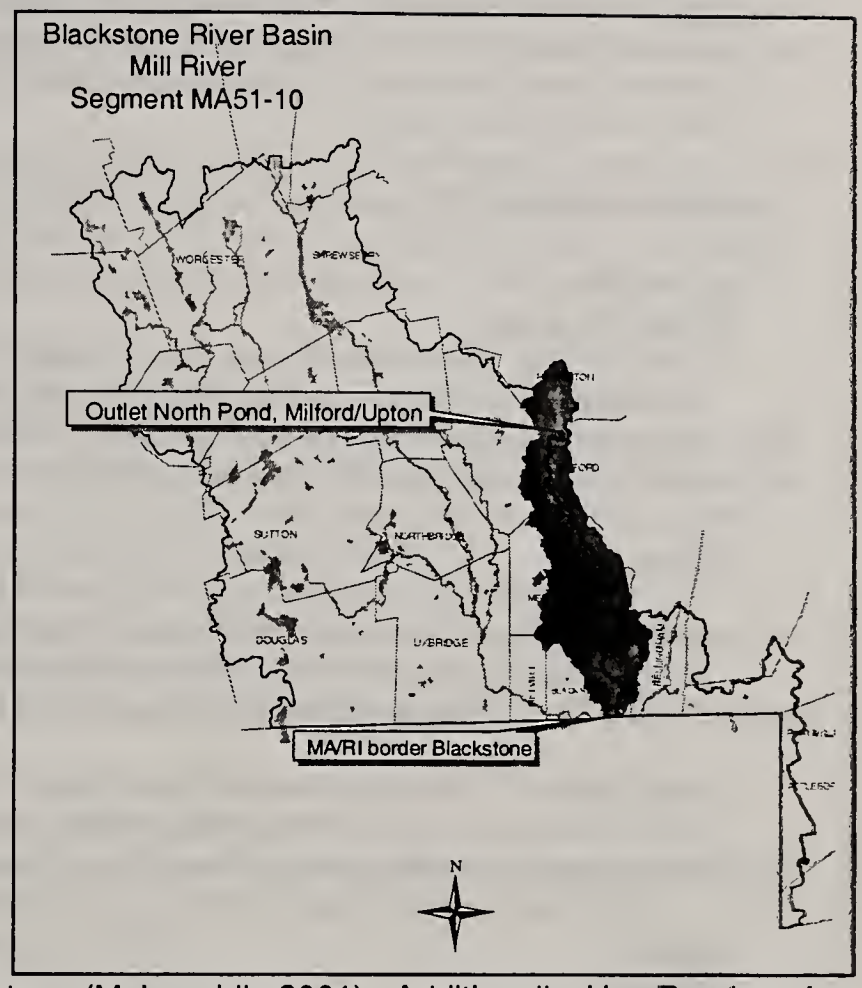
- Continue to support the US ACOE Aquatic Habitat Restoration Study ongoing on the Blackstone River from Fisherville Pond to the Rhode Island border and evaluate the data/analyses as they become available.

- Evaluate the effectiveness of UMASS's pilot project in stabilizing and reducing contamination in Rice City Pond (Lanza and Xing 1999).

- In the next revision of the Massachusetts Surface Water Quality Standards, with DFWELE, consider designating Fox Brook as a cold water fishery.

## MILL RIVER (SEGMENT MA51-10)

Location: Outlet North Pond, Milford/Upton to MA/RI border, Blackstone, MA.
Segment Length: 16.1 miles.
Classification: Class B, Warm Water Fishery.




Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 60% |
| Residential | 21% |
| Agriculture | 7% |

The use assessments of North, Fiske Mill, Mill, Hopedale, Spindleville and Harris ponds are provided in the Lakes Assessment section of this report (Tables 5 and 6).

In August 1973, DFWELE (Project No. F-36-R-6) conducted a fish population survey in the Mill River. Twelve species of fish including, in order of dominance, tesselated darter, largemouth bass, bluegill, yellow bullhead, pumpkinseed, fallfish and blacknose dace, unidentified cyprinids, brown trout, chain pickerel, and two individuals each of redfin pickerel and yellow perch were collected (DFWELE undated). In 1982 DFWELE also identified American brook lamprey, a threatened species in Massachusetts, in the Mill River in Mendon/Blackstone (McLaughlin 2001). Additionally, Hop Brook and Quick Stream in Blackstone, Muddy and Spring brooks in Mendon, all tributaries to the Mill River, were identified by DFWELE as supporting native brook trout based on surveys conducted in 1987, 1983, 1994 and 1984 respectively (McLaughlin 2001).

### *WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):*

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (# days if < 365) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Hopedale Water Department | 2138000 | | 21213802 | 2138000-01G | 0.41 MGD | 0.48 MGD* |
| Hopedale Country Club | | | 21213801 | Mill River | 0.1 MGD (240 days) | 0.03 MGD |
| Blackstone Water Department | 2023000 | 9P21203201 | 21203201 | 2032000-05G<br>2032000-01G<br>2032000-02G<br>2032000-06G<br>2032000-07G<br>2032000-04G<br>2032000-08G | 0.95 MGD | 0.79 MGD |

*Withdrawal did not exceed registration amount by more than 0.1 MGD (WMA threshold)

### *NPDES WASTEWATER DISCHARGE SUMMARY:*

Hopedale WWTP (MA0102202) is permitted (September 1999) to discharge 0.588 MGD of treated wastewater via outfall #001 to this segment of the Mill River. The permit limits for whole effluent toxicity are $LC_{50} \geq 100\%$ and CNOEC $\geq 57\%$. The facility appealed their copper limit (Mounce 2000).

### *OTHER:*

Waste Site #2-0000765 Draper Landfill, 161 Freedom St., Hopedale. The site is currently listed as a TIER 1B (defined as: a site/release where the responsible party fails to provide a required submittal to DEP by a specified deadline). The DEP's Bureau of Waste Site Cleanup is now considering actions to correct the non-compliance and the conduct of appropriate response actions at the site. It was originally listed as a

location to be investigated based on studies done by DWM--specifically the technical memorandum for the record entitled "Draper Mill Area Surface Water and Sediment Characterization, Hopedale, MA." (Szal 1990) and the memorandum entitled " 1990 Mill River Fish Toxics Monitoring" (Maietta 1991). Low levels of metals and PCB in Mill River sediments and fish fillets were documented and the Draper Landfill was noted as a likely source of contamination. The DPH fish advisory for the Mill River is described below (*Fish Consumption Use*).

## USE ASSESSMENT

### *AQUATIC LIFE*

Habitat and Flow

The Mill River (downstream from Park Street, Blackstone) received one of the highest habitat scores in the Blackstone River watershed (Appendix C). The only habitat parameters to score poorly were sediment deposition and embeddedness. There have been some concerns expressed by residents regarding abnormally low flows in the Mill River in recent years (Cohen 2001).

Biology

In July 1998 DWM conducted a RBP III benthic macroinvertebrate survey at one station on this segment of the Mill River (Appendix C): BLK15-1 - Mill River downstream from Park Street, Blackstone. The benthic community was 81% comparable (non-impaired) to both the Mumford River regional reference station (BLK09-8A) and the Kettle Brook reference station (KB10).

Fish population sampling was also conducted on the Mill River (station BLK15-1) downstream from Park Street, Blackstone by DWM in August 1998. Eight fish species were collected, the second most diverse assemblage in the Blackstone River Basin during the 1998 DWM fish survey (Appendix C).

Toxicity

*Effluent*

Hopedale WWTP conducted whole effluent toxicity tests using *P. promelas* on a quarterly basis between March 1996 and September 1999 using laboratory water for diluent. Acute toxicity ($LC_{50}$ = 36.2%) was detected in one of 14 sampling events (December 1996) while chronic toxicity was detected in six of the 14 tests (CNOEC ranging between <6.25% and 57% effluent), however only three of the chronic results were < 57% (the effluent limit). The new permit requires toxicity testing with *C. dubia*. No acute toxicity was detected in the two tests conducted in November 1999 and February 2000, while CNOEC results were both 57% effluent.

Chemistry – water

DWM physico-chemical water quality sampling was conducted once at station BLK15-1 (upstream, of Summer/Park Street, Blackstone) (Appendix B, Figure B1). No obvious water quality problems were noted (Appendix B, Tables B5 and B6).

The *Aquatic Life Use* for the upper 5.4 mile reach of this segment is currently not assessed. The lower 10.7 miles (from the Hopedale WWTP discharge to the MA/RI state line) is assessed as support based on benthic macroinvertebrate data that indicates no impairment. The *Aquatic Life Use* is however on "Alert Status" for one mile downstream of the Hopedale WWTP discharge due to effluent toxicity.

### *FISH CONSUMPTION*

In May 1992, DPH issued a fish consumption advisory for the Mill River based on fish toxics monitoring data generated by DEP in 1990 (Oleru 1992 and Maietta 1991). The 1992 advisory stated that although PCB levels were not above the FDA action limit, because of the health concerns associated with exposure to the developing fetus and child as well a concerns associated with long-term exposure and the potential cancer risk, that:

1. "Pregnant women and nursing mothers should not eat any fish species from the Mill River in order to prevent exposure of developing fetuses and infants to PCBs, and
2. Consumption of all fish from the Mill River should be limited to two meals per month per person."

The advisory has changed slightly and now recommends the following (MA DPH 1999):

1. "Children younger than 12 years, pregnant women and nursing mothers should not eat any fish the Mill River in Hopedale in order to prevent exposure of developing fetuses and infants to PCBs, and
2. The general public should limit consumption of all fish from the Mill River in Hopedale to two meals per month."

It should be noted that PCB levels in edible fish fillets collected from Hopedale Pond in 1990 were below quantifiable levels whereas PCB levels from Spindleville Pond (approximately 1.7 miles downstream from Hopedale Pond) exceeded the MA DPH trigger level of 1.0 ppm. The current advisory on the Mill River will likely be modified to specify the reach between the outlet of Hopedale Pond and the Spindleville Impoundment Dam (Maietta 2001).

Although not included in the current advisory, it should be also be noted that elevated mercury concentrations (exceeding MA DPH trigger level of 0.5 ppm) were detected in fish from Hopedale Pond as well as a station in the Mill River in the town of Blackstone. Since the time of the original advisory for Mill River, the trigger level for mercury was lowered. The MA DPH has been notified of the apparent discrepancy between the mercury data and the current advisory (Maietta 2001).

MA DPH is currently re-evaluating the data for a potential modification to the existing advisory. Based on the elevated levels of PCB in edible fish fillets from Spindleville Pond, the *Fish Consumption Use* is assessed as non-support for the 1.7-mile length of the Mill River between the outlet of Hopedale Pond and the Spindleville Pond Dam, Hopedale.

***PRIMARY CONTACT AND SECONDARY CONTACT RECREATION***

In July 1998 DWM collected fecal coliform bacteria samples the same location as the water quality data (Appendix B, Table B7). The fecal coliform bacteria count (replicate sample) was 80 and 100 cfu/100mLs. The samples represented dry weather conditions.

Too limited instream fecal coliform bacteria data was available to assess either of the recreational uses therefore *Primary* and *Secondary Contact* uses are currently not assessed.

***AESTHETICS***

The DWM biosurvey indicated good (high habitat quality, low suspended solids and turbidity) aesthetics quality at station BLK15-1—Mill River, downstream from Park Street, Blackstone (Appendix C).

The *Aesthetics Use* for the upper 5.4 mile reach of this segment is currently not assessed. Based on the above information the *Aesthetics Use* is assessed as support for the lower 10.7 miles (from the Hopedale WWTP discharge to the MA/RI state line) of the Mill River.

Mill River (MA51-10) Use Summary Table

| Designated Uses | | Status | Causes | | Sources | |
|---|---|---|---|---|---|---|
| | | | Known | Suspected | Known | Suspected |
| Aquatic Life* |  | NOT ASSESSED upper 5.4 miles<br>SUPPORT lower 10.7 miles | | | | |
| Fish Consumption |  | NOT ASSESSED upper 5.1 miles and lower 9.3 miles<br>NON-SUPPORT 1.7 miles | PCB | | Unknown | |
| Primary Contact |  | NOT ASSESSED | | | | |
| Secondary Contact |  | NOT ASSESSED | | | | |
| Aesthetics |  | NOT ASSESSED upper 5.4 miles<br>SUPPORT lower 10.7 miles | | | | |

* "Alert Status" issues identified

**RECOMMENDATIONS MILL RIVER (MA51-10)**

- Recommendations quoted from Appendix C – 1998 DEP DWM Biomonitoring Technical Memorandum.

  Possible sources of instream sedimentation in the Mill River may be the erosional activity of naturally-sandy flood plain soils in the sub-basin, or NPS inputs (e.g., from the upstream road crossing). Certainly, numerous sand and gravel operations adjacent to the river are potential NPS stressors, and their activities may warrant further investigation (i.e., site visits). Improvements to the stream's riparian zone (e.g., vegetative restoration) in the small park just upstream from BLK15-1 and the Summer Street crossing may help reduce NPS inputs in this area.

- The Hopedale WWTP (MA0102202) should collect water from the Mill River upstream of their discharge to use as dilution water in their whole effluent toxicity tests. If the river water does not meet the control test acceptability criteria (e.g., survival > 80% at 7-day), then the river water must still be utilized as a test control but not diluent. The facility must also request and receive written approval, if necessary, to utilize an alternate standard dilution water with similar hardness to that of the Mill River. If toxicity test results do not meet permit limits (frequency and severity of violations considered), a toxicity identification and reduction evaluation and/or an instream biological monitoring evaluation may be warranted/required. Additional monitoring should be conducted to evaluate the effectiveness of dechlorination and to determine if there are any near-field instream impacts.

- Additional monitoring should be conducted in the Mill River to better evaluate the source, level and spatial extent of heavy metal (e.g., mercury, etc.) and PCB contamination. Types of monitoring should include, but not necessarily be limited to, sediment quality sampling and bioaccumulation studies.

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

- In the next revision of the Massachusetts Surface Water Quality Standards, with DFWELE, consider designating the Mill River and the following rivers in its subwatershed as cold water fisheries: Hop, Muddy and Spring brooks and Quick Stream.

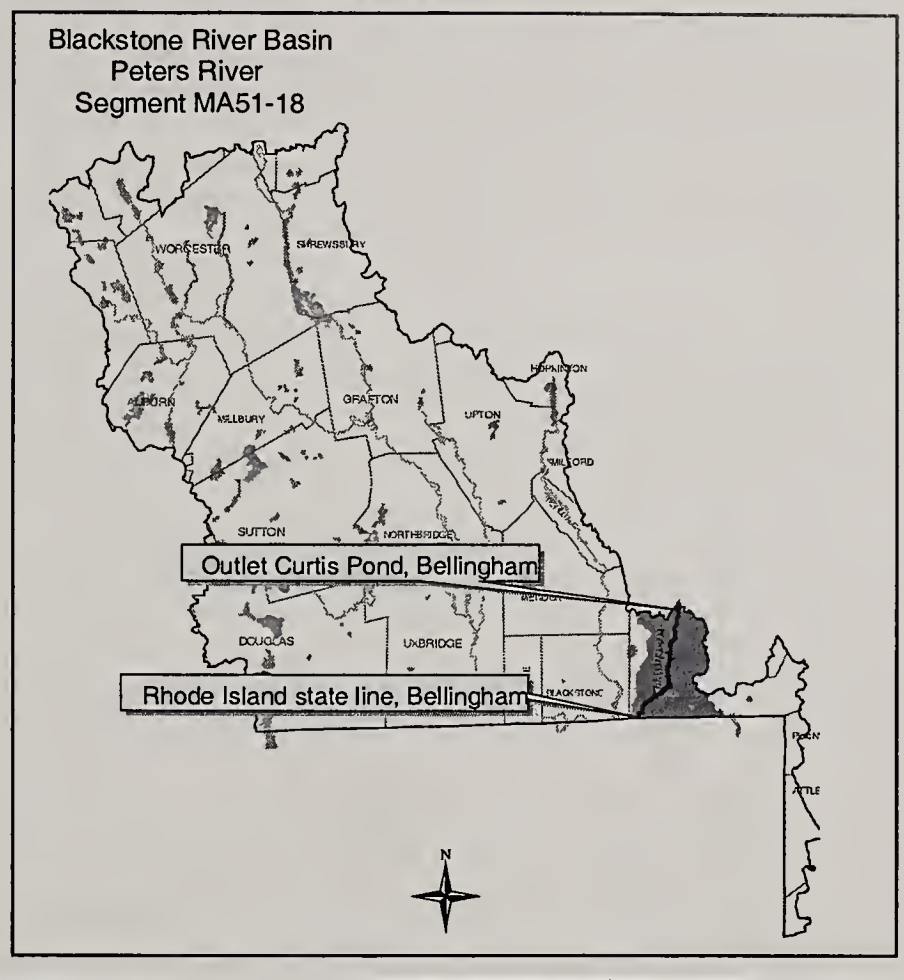
## PETERS RIVER (SEGMENT MA51-18)

Location: Outlet Curtis Pond, Bellingham to Rhode Island state line, Bellingham.
Segment Length: 7.1miles.
Classification: Class B.

Land-use estimates for the subwatershed (map inset, gray shaded area):

| | |
|---|---|
| Forest | 57% |
| Residential | 22% |
| Agriculture | 9% |

The use assessment of Silver Lake is provided in the Lakes Assessment section of this report (Table 5).




***WMA WATER WITHDRAWAL SUMMARY (APPENDIX D, TABLE D2):***

| Facility | PWS ID# | WMA Permit # | WMA Registration # | Source | Authorized Withdrawal (# days if < 365) | 1998 Average Withdrawal |
|---|---|---|---|---|---|---|
| Bellingham Water Department | 2025000 | 9P21202502 | 21202501 | 2025000-01G<br>2025000-02G<br>2025000-04G<br>2025000-11G<br>2025000-03G | 1.74 MGD | 1.39 MGD |
| New England Country Club | | 9P21202501 | | Pond | 0.31MGD (180 days) | 0.09 MGD in 1999 |

***NPDES WASTEWATER DISCHARGE SUMMARY:***
Based on the available information, there are no regulated surface water discharges the Peters River.

**USE ASSESSMENT**
No current data/information were available therefore all uses for Peters River are currently not assessed.

Peters River (MA51-18) Use Summary Table

| Aquatic Life | Fish Consumption | Primary Contact | Secondary Contact | Aesthetics |
|---|---|---|---|---|
|  |  |  |  |  |
| Not Assessed | | | | |

**RECOMMENDATIONS**

- Evaluate compliance with WMA registration and/or permit limits. Determine potential impacts of withdrawals on streamflow/habitat.

## BLACKSTONE RIVER BASIN - LAKE ASSESSMENTS

A total of 188 lakes, ponds or impoundments (the term "lakes" will hereafter be used to include all) covering 7,086.6 acres have been identified and assigned Pond and Lake Information System (PALIS) code numbers in the Blackstone River Basin (Ackerman 1989 and MA DEP 2000d). This report presents information on the lakes in the DWM/EPA WBS database. These 138 lakes (6,743.6 acres), represent 95% of the total lake acreage in the basin (Tables 5 and 6). The remaining 50 lakes in the Blackstone River Basin are unassessed; they are not currently included as segments in the DWM/EPA WBS database.

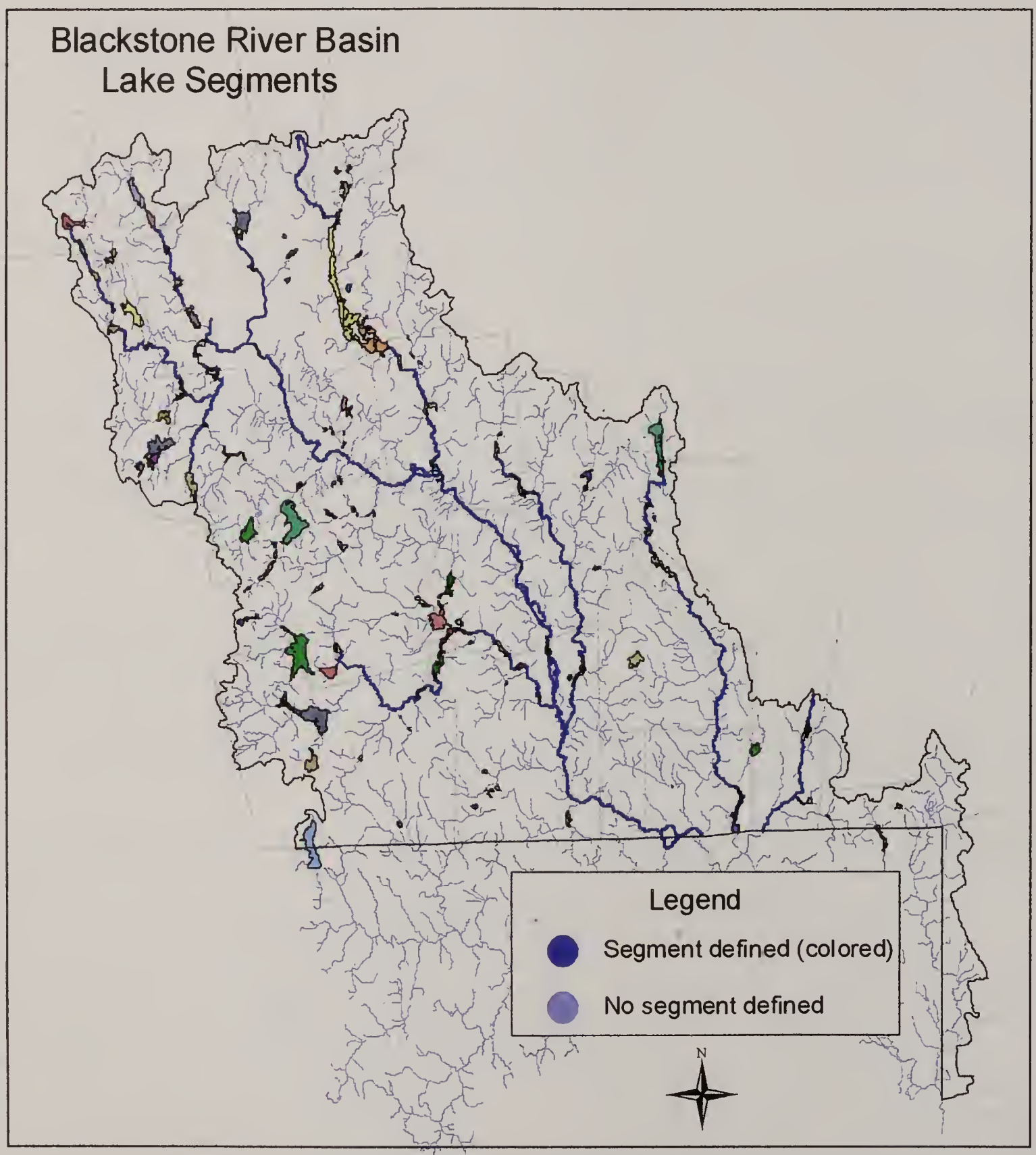



Figure 6. Location of lakes assessed in the Blackstone River Basin.

## BLACKSTONE RIVER BASIN – LAKE SEGMENT ASSESSMENTS

The 138 lakes assessed in this report lie wholly or partly within 22 of the basin's 30 communities (Figure 6). Many of the basin's lakes are relatively small, in fact 103 of the 138 lakes in this report have surface areas less than 50 acres. Synoptic surveys were conducted by DWM in 37 of these lakes in 1998 (Appendix B, Table B9).

## TROPHIC STATUS EVALUATION

Lakes are dynamic ecosystems that over time undergo a process of succession from one trophic state to another. Under natural conditions most lakes move from a nutrient poor (oligotrophic) condition through an intermediate (mesotrophic) stage of nutrient availability and biological productivity to a nutrient-rich or highly productive (eutrophic) state. For the purposes of this report trophic status has been estimated primarily using visual observations of macrophyte cover and phytoplankton populations. Occasionally, older data from more detailed diagnostic studies were utilized. A more definitive assessment of trophic status would require more extensive collection of water quality and biological data. The trophic status estimates, for the lakes assessed in the Blackstone River Basin, are presented in Tables 5 and 6. Where trophic status was estimated approximately 9% were oligotrophic, 35% were mesotrophic, and 41% were eutrophic. Four percent of the lakes were estimated to be hypereutrophic. Trophic status was undetermined in 8% of the lakes. In cases where a dam control structure was breached or aquatic plant density reduced ponds to channels and marshlands, the evaluation of the trophic status was not applicable (3%).

## LAKE USE ASSESSMENTS

Lake assessments are based on information gathered during DWM surveys (recent and historic) as well as pertinent information from other sources (e.g., abutters, herbicide applicators, diagnostic/feasibility studies, DPH, etc.). The 1998 DWM synoptic surveys focused on observations of water quality and quantity (e.g., water level, sedimentation, etc.), the presence of native and non-native aquatic plants (both distribution and areal cover) and presence/severity of algal blooms (Appendix B). In-lake measurements of dissolved oxygen, pH, temperature and sampling for nutrients, chlorophyll *a* and fecal coliform bacteria, would have provided sufficient data to completely assess the status of the *Aquatic Life* and *Primary Contact Recreational* uses and were generally not readily available. When no visual impairment was identified during the synoptic surveys, it could not be assumed that water quality conditions met standards and, therefore, neither the *Aquatic Life* nor *Primary Contact Recreational* uses could be assessed as support – they are not assessed. In the case of the *Fish Consumption Use*, fish consumption advisory information was obtained from the Department of Public Health (MA DPH 1999). Although the *Drinking Water Use* was not assessed in this water quality assessment report, the Class A waters were identified. Information on drinking water source protection and finish water quality is available at http://www.state.ma.us/dep/brp/dws/dwshome.htm and from the Blackstone River Basin's public water suppliers.

In cases where a dam control structure was breached and/or aquatic plant densities reduced a lake to channels and marshlands, the affected acreage was considered perennially lost. The area of this perennial 'loss' was determined by overlaying the field observations (MA DEP 2000c) on the MassGIS Hydrography (1:25,000) Datalayer (EOEA 1998) and calculating the 'new' acreage of the lake. The designated uses for the areas of perennial loss were considered not attainable. DWM synoptic surveys in 1994 found this to be the case for six lakes (Forge, Mayo, Merrill No.6, Middle River, Thompson, Williams Street ponds) and portions of four lakes (City Farm Pond, Curtis Pond, Rice City Pond and Sibley Reservoir) totaling 175 acres in the Blackstone River Basin.

The use assessments and supporting information were entered into the EPA Water Body System database. Data on the presence of non-native plants were entered into the DEP DWM informal non-native plant tracking database.

### *AQUATIC LIFE*

Non-native aquatic macrophytes were observed in 23 (62%) of the 37 lakes surveyed by DWM in 1998 (Appendix B, Table B9). The four non-native aquatic species observed in the Blackstone River Basin

lakes were *Myriophyllum spicatum* - Eurasian water milfoil, *M. heterophyllum* – variable milfoil, *Najas minor* – bushy pondweed, and *Cabomba caroliniana* – fanwort. These species have high potential for spreading and are likely to have established themselves in downstream lake and river segments in the Blackstone River Basin which may not been surveyed. Table 4 indicates where these non-native aquatic species were observed (**in bold**) during the DWM 1998 surveys and the likely, or potential, avenues of downstream spreading.

Additionally, *M. heterophyllum*, is suspected in 12 lakes in the basin; Caprons Pond (Uxbridge), Eddy Pond (Auburn), Ironstone Reservoir (Uxbridge), Jenks Reservoir (Bellingham), Pratt Reservoir (Worcester), Silver Lake (Grafton), Tinker Hill Pond ((Auburn), Wildwood Lake (Upton/Grafton), Lake Ripple (Grafton), Whitins Pond (Northbridge/Sutton), Manchaug Pond (Douglas/Sutton), and Waite Pond (Leicester). At the time of the DWM surveys, these plants were not developed enough to precisely identify them as *M. heterophyllum*.

In August 1999, *N. minor* was identified by DWM and CERO personnel in the north cove (approximately six acres) of Dorothy Pond in Millbury (Beaudoin 2001). This non-native has a high potential for spreading and could likely be established downstream (from Dorothy Pond into Dorothy Brook, through Woolshop Pond, into an unnamed tributary and then into the Blackstone River).

The *Aquatic Life Use* was assessed as either partial or non-support in lakes with confirmed non-native macrophyte(s) depending on the degree of biocommunity modification (Table 5). However, if non-native macrophytes were not present in a lake, it or part of its area, was listed as "not assessed" because of the cursorial nature of the observations and the lack of dissolved oxygen data. This use was not attainable in six lakes and in portions of four lakes due to flow alteration and perennial 'loss' of pond acreage (175 acres).

Table 4. Non-native aquatic plant species locations (**in bold**) observed in 1998 in the Blackstone River Basin and their possible paths of downstream spreading.

| ***Cabomba caroliniana*** **(Fanwort)** |
|---|
| **Newton Pond** (Shrewsbury/Boylston) ⇒Quinsigamond River, through Mud Pond, Brooklawn Parkway Pond, Shirley Street Pond (Shrewsbury), Lake Quinsigamond (Shrewsbury/Worcester) ⇒ **Flint Pond north basin** (Shrewsbury) ⇒ **Flint Pond south basin** (Shrewsbury/Worcester/Grafton) ⇒ Hovey Pond (Grafton) ⇒ and **Lake Ripple*** (Grafton) ⇒ Fisherville Pond (Grafton) an impoundment of the Blackstone River through Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border<br>**Cook Pond** (Worcester) ⇒ Tatnuck Brook through Patch Reservoir, ⇒ unnamed tributary through Coes Reservoir ⇒ unnamed tributary ⇒ Middle River ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border |
| **Stoneville Pond** (Auburn) an impoundment of Kettle Brook ⇒ Leesville Pond (Auburn/Worcester) ⇒ unnamed tributary ⇒ Curtis Pond south basin (Worcester) ⇒ Curtis Pond north basin (Worcester) ⇒ Middle River ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border |
| **Manchaug Pond*** (Sutton/Douglas) ⇒ unnamed tributary ⇒ Stevens Pond (Sutton) ⇒ unnamed tributary ⇒ Mumford River (Sutton) through Gilboa Pond (Douglas), Lackey Pond (Uxbridge/Sutton), **Meadow Pond** (Sutton/Northbridge), **Linwood Pond** (Northbridge), **Whitin Pond** and **Caprons Pond*** (Uxbridge) ⇒ Blackstone River (Uxbridge) to the Massachusetts/Rhode Island border |
| **Whitins Pond*** (Northbridge/Sutton) through an unnamed impoundment ⇒ **Meadow Pond** an impoundment of the Mumford River through **Linwood Pond** (Northbridge), **Whitin Pond** and **Caprons Pond*** (Uxbridge) ⇒ Blackstone River (Uxbridge) to the Massachusetts/Rhode Island border |
| **Lake Wildwood*** (Upton/Grafton) an impoundment of the West River, through Williams Street Pond (Upton), **West River Pond** (Uxbridge) ⇒ Blackstone River (Uxbridge) to the Massachusetts/Rhode Island border |
| **Ironstone Reservoir*** (Uxbridge) an impoundment of Bacon Brook ⇒ Blackstone River (Uxbridge) to the Massachusetts/Rhode Island border |
| **Hopedale Pond** (Hopedale) an impoundment of the Mill River, through Spindleville Pond (Hopedale) and **Harris Pond** (Blackstone) to the Massachusetts/Rhode Island border |

* a milfoil species is present in this pond but is unconfirmed as being *M. heterophyllum*

Table 4. Continued. Non-native aquatic plant species locations (**in bold**) observed in 1998 in the Blackstone River Basin and their possible paths of downstream spreading.

| |
|---|
| ***Najas minor*** **(Bushy pondweed)** |
| **Tinker Hill Pond*** (Auburn) ⇒ unnamed tributary ⇒ **Dark Brook Reservoir south basin** (Auburn) ⇒ unnamed tributary ⇒ Dark Brook Reservoir north basin (Auburn) ⇒ Dark Brook ⇒ an unnamed impoundment ⇒ Stoneville Pond (Auburn) an impoundment of Kettle Brook ⇒ Leesville Pond (Auburn/Worcester) ⇒ unnamed tributary ⇒ Curtis Pond south basin (Worcester) ⇒ Curtis Pond north basin (Worcester) ⇒ Middle River ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border |
| ***Myriophyllum heterophyllum*** **(Variable water milfoil)** |
| **Newton Pond** (Shrewsbury/Boylston) ⇒Quinsigamond River, through Mud Pond, Brooklawn Parkway Pond, Shirley Street Pond (Shrewsbury), Lake Quinsigamond (Shrewsbury/Worcester) ⇒ Flint Pond north basin (Shrewsbury) ⇒ **Flint Pond south basin** (Shrewsbury/Worcester/Grafton) ⇒ Hovey Pond (Grafton) ⇒ and Lake Ripple* (Grafton) ⇒ Fisherville Pond (Grafton) an impoundment of the Blackstone River through Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border<br>**Tuckers Pond** (Sutton) ⇒ Mumford River (Sutton) through Gilboa Pond (Douglas), Lackey Pond (Uxbridge/Sutton), Meadow Pond (Sutton/Northbridge), Linwood Pond (Northbridge), Whitin Pond and Caprons Pond* (Uxbridge) ⇒ Blackstone River (Uxbridge) to the Massachusetts/Rhode Island border<br>**Hopedale Pond** (Hopedale) an impoundment of the Mill River, through Spindleville Pond (Hopedale) and Harris Pond (Blackstone) to the Massachusetts/Rhode Island border |
| ***Myriophyllum spicatum*** **(Eurasian water milfoil)** |
| **Flint Pond north basin** (Shrewsbury) ⇒ **Flint Pond south basin** (Shrewsbury/Worcester/Grafton) ⇒ Hovey Pond (Grafton) ⇒ and Lake Ripple* (Grafton) ⇒ Fisherville Pond (Grafton) an impoundment of the Blackstone River through Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border<br>**Coes Reservoir** (Worcester) ⇒ unnamed tributary ⇒ Middle River ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border<br>**Dark Brook Reservoir south basin** (Auburn) ⇒ unnamed triburary ⇒ **Dark Brook Reservoir north basin** (Auburn) ⇒ Dark Brook ⇒ an unnamed impoundment ⇒ Stoneville Pond (Auburn) an impoundment of Kettle Brook ⇒ Leesville Pond (Auburn/Worcester) ⇒ unnamed tributary ⇒ Curtis Pond south basin (Worcester) ⇒ Curtis Pond north basin (Worcester) ⇒ Middle River ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border<br>**Singletary Pond** (Sutton/Millbury) ⇒ Singletary Brook through Brierly Pond (Millbury) ⇒ Blackstone River through Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge) to the Massachusetts/Rhode Island border |

* a milfoil species is present in this pond but is unconfirmed as being *M. heterophyllum*

Two non-native wetland species, *Lythrum salicaria* (purple loosestrife) and *Phragmites australis* (reed grass) were identified at 20 (54%) of the lakes surveyed by DWM in 1998 (Appendix B, Table B9). Although the presence of these species is not generally a cause of impairment to lakes, their invasive growth habit can result in the impairment of wetland habitat associated with lakes.

### *FISH CONSUMPTION*

In 1994 DPH issued a statewide "Interim Freshwater Fish Consumption Advisory" stating that "pregnant women should be advised of the possible health risk from eating fish from Massachusetts freshwater bodies in order to prevent exposure of developing fetuses to mercury" (MA DPH 1994). This precautionary measure was aimed at pregnant women only; the general public was not considered to be at risk from fish consumption. DPH's interim advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially. The advisory encompasses all freshwaters in Massachusetts and therefore the *Fish Consumption Use* for lakes in the Blackstone River Basin can not be assessed as support or partial support.

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Waterbodies with DPH fish consumption advisories were assessed as non-support for the *Fish Consumption Use* (Table 5). Specific advisories have been issued by DPH for three lakes in the Blackstone River Basin (Riverdale, Rice City, and Waite ponds) because of health concerns associated with exposure to contaminants (MA DPH 1999). Additionally there is an advisory for the Mill River in Hopedale, which includes Spindleville Pond. These advisories are listed below:

DPH has issued a fish consumption advisory due to PCB contamination for Riverdale and Rice City ponds.

Riverdale Pond, Northbridge:

1. "Children under 12, pregnant women and nursing mothers should not consume fish from Riverdale Pond in order to prevent exposure of developing fetuses and young children to PCBs."
2. "The general public should limit consumption of all fish species from Riverdale Pond to two meals per month."

Rice City Pond, Uxbridge/Northbridge:

1. "Children under 12, pregnant women and nursing mothers should not consume any fish from Rice City Pond in order to prevent exposure of developing fetuses and young children to PCBs."
2. "The general public should not consume any carp from Rice City Pond."

DPH has issued a fish consumption advisory due to mercury contamination for Waite Pond, Leicester:

1. "Children under 12, pregnant women and nursing mothers should not consume any fish from Waite Pond in order to prevent exposure of developing fetuses and young children to mercury."
2. "The general public should limit consumption of all fish species from Waite Pond to two meals per month."

In 1999 DPH updated an existing advisory to the Mill River, Hopedale and recommended the following:

1. "Children younger than 12 years, pregnant women and nursing mothers should not eat any fish from the Mill River in Hopedale in order to prevent exposure of developing fetuses and infants to PCBs, and
2. The general public should limit consumption of all fish from the Mill River in Hopedale to two meals per month."

DPH is currently re-evaluating all existing data for a potential modification to the Mill River, Hopedale advisory. An updated advisory will likely specify the reach of the Mill River between the outlet of Hopedale Pond and the Spindleville Impoundment Dam (Maietta 2001).

In response to public information requests, DWM sampled fish in Lake Quinsigamond and Wallum Lake in 1996 and Hovey Pond in 1996/1997 (Maietta 1997).

In 1998 fish were sample from University Park Pond and Coes Reservoir in Worcester by DWM at the request of the Blackstone River Watershed Team for human consumption considerations. PCB and mercury concentrations were below DPH action levels (2.0 and 0.5 ppm, respectively) in both of these lakes (Appendix B, Table B8, Maietta 1997).

The *Fish Consumption Use* was not attainable in six lakes and in portions of four lakes due to flow alteration and 'loss' of pond acreage (175 acres).

[NOTE: The DPH fish consumption advisory list contains the status of each water body for which an advisory has been issued. If a water body is not on the list, it may be because either an advisory was not warranted or the water body has not been sampled. DPH's most current Fish Consumption Advisory list is available online at http://www.state.ma.us/dph/beha/fishlist.htm.)

### *PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS*

In 1998 DWM conducted synoptic surveys of 37 lakes in the Blackstone River Basins. These included observations of water quality and quantity, the presence of native and non-native aquatic plants (and presence/severity of algal blooms (Appendix B, Table B9). These data combined with older assessment information, the 1998 303(d) list of impaired waters, and diagnostic/feasibility studies, etc., were used to assess the recreational and aesthetics uses.

In the absence of fecal coliform bacteria and Secchi disk depth data, the assessment of the recreational uses was based primarily on the survey information described above. Depending upon the severity of these conditions the recreational and aesthetics uses were assessed as either partial or non-support. Where no objectionable conditions were noted, the *Primary Contact Recreational Use* was not assessed due to the lack of fecal coliform bacteria data.

No lakes in the Blackstone River Basin were assessed as supporting the *Primary Contact Recreational Use*. The *Primary Contact Recreational Use* was impaired (partial or non-support) for part or all of 84 lakes (1,752 acres; 26% of the total acreage assessed in this report) in the Blackstone River Basin (Table 5). Causes of impairment included noxious/overabundant plant growth (both native and non-native vegetation), taste/odor/color, objectionable turbidity, and/or flow alteration. The *Primary Contact Recreational Use* was not assessed for 31 lakes (4756.6 acres). This use was not attainable in six lakes and in portions of four lakes due to flow alteration and 'loss' of pond acreage (175 acres).

The *Secondary Contact Recreational* and *Aesthetics* uses were assessed as support in all or portions of 38 lakes (2,560 acres) in the Blackstone River Basin (38% of the total acreage assessed in this report). Seventy-eight of the assessed lakes (wholly or in-part) had a high degree/density of macrophyte cover (noxious plants) which resulted in the *Secondary Contact Recreational* and *Aesthetic* uses being impaired (partial or non-support) (Table 5). These uses were not assessed for 27 lakes (2,196.7 acres). These uses were not attainable in six lakes and in portions of four lakes due to flow alteration and 'loss' of pond acreage (175 acres).

### SUMMARY

A total of 110 of the 138 lakes assessed in this report were impaired for one or more uses. Causes of impairment included noxious (overabundant) plant growth (including both native and non-native vegetation), PCB and/or mercury contamination, taste/odor/color, objectionable turbidity, and/or flow alteration. Eighteen lakes were assessed as support for the *Secondary Contact Recreational* and A*esthetics* uses. No lakes supported all uses nor were any assessed as support for either the *Aquatic Life* or *Primary Contact Recreational* uses. Twenty-two lakes are currently not assessed for all uses (Table 6) while the uses were not attainable in six lakes due to flow alteration and perennial 'loss' of pond acreage.

With the exception of mercury and PCB, the overall causes of impairment may be indicative of enrichment (accelerating natural lake succession) as evidenced by the trophic status estimates; of the 138 lakes included in this report 57% were estimated to be eutrophic. Site-specific sources of impairment to the lakes in the Blackstone River Basin are largely unknown. However, nutrient enrichment from storm water runoff, failing/substandard sewage disposal systems, and/or drainage from agricultural lands are likely to have increased the macrophyte productivity resulting in impairments to the *Aquatic Life*, *Recreational,* and *Aesthetics* uses.

Four lakes, totaling 175 acres, in the Blackstone River Basin were impaired for the *Fish Consumption Use* because of either PCB or mercury contamination.

Table 5 presents the use assessments and causes of impairment for the lakes in the Blackstone River Basin. If a designated use (e.g., *Aquatic Life* -ALUS, *Fish Consumption, Drinking Water,* etc.) is not presented in the use assessment column, it was not assessed. Twenty-two of the 138 lakes in the DWM/EPA WBS database were not assessed during this assessment cycle (Table 6), however six of these lakes are on the 1998 303(d) list of impaired waters.

Table 5. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| **Aldrich Pond, Sutton** | **MA51002** | 2 | E | ALUS- P(2)<br>1° Contact- N(2)<br>2° Contact- N(2)<br>Aesthetics- N(2) | Noxious plants<br>Non-native plants (Mh) |
| **Arcade Pond, Northbridge** | **MA51003** | 18 | E | ALUS- P(18) | Non-native plants (Cc) |
| **Auburn Pond, Auburn** | **MA51004** | 16 | E | ALUS- P(16)<br>1° Contact- N(12);U(4)<br>2° Contact- N(12);U(4)<br>Aesthetics- N(12);U(4) | Noxious plants<br>Non-native plants (Cc) |
| **Brierly Pond, Milbury** | **MA51010** | 18 | M | ALUS- P(18)<br>1° Contact- N(5);U(13)<br>2° Contact- N(5);U(13)<br>Aesthetics- N(5);U(13) | Noxious plants<br>Non-native plants (Mh) |
| **Brooklawn Parkway Pond, Shrewsbury** | **MA51195** | 2 | E | 1° Contact- N(2)<br>2° Contact- N(2)<br>Aesthetics- N(2) | Noxious plants |
| Caprons Pond, Uxbridge | MA51014 | 15 | E | ALUS- P(15)<br>1° Contact- N(13);U(2)<br>2° Contact- S(2);N(13)<br>Aesthetics- S(2);N(13) | Noxious plants<br>Non-native plants (Cc) |
| Carpenter Reservoir, Northbridge | MA51015 | 86 | M | 2° Contact- S(86)<br>Aesthetics- S(86) | |
| **Chase Pond, Douglas** | **MA51017** | 11 | E | 1° Contact- N(11)<br>2° Contact- N(11)<br>Aesthetics- N(11) | Noxious plants |
| **Cider MillPond, Grafton** | **MA51019** | 4 | E | 1° Contact- N(3);U(1)<br>2° Contact- N(3);U(1)<br>Aesthetics- N(3);U(1) | Noxious plants |
| **City Farm Pond, Shrewsbury** | **MA51020** | 2 | E (1)<br>Not applicable (1) | ALUS- U(1);NA(1)<br>Fish Consumption- U(1); NA(1)<br>1° Contact- U(1);NA(1)<br>2° Contact- U(1);NA(1)<br>Aesthetics- U(1);NA(1) | Noxious plants<br>Siltation |
| **Clark Reservoir, Sutton** | **MA51022** | 32 | E | 1° Contact- N(15);U(17)<br>2° Contact- S(17);N(15)<br>Aesthetics- S(17);N(15) | Noxious plants |
| Coes Reservoir, Worcester | MA51024 | 90 | E | ALUS- P(90)<br>2° Contact- S(90)<br>Aesthetics- S(90) | Non-native plants (Ms) |
| Cook Pond, Worcester | MA51027 | 20 | E | ALUS- P(4);N(16)<br>1° Contact- N(20)<br>2° Contact- N(20)<br>Aesthetics- N(20) | Flow alteration<br>Noxious plants<br>Non-native plants (Cc) |
| **Crane Pond, Blackstone** | **MA51030** | 11 | E | 1° Contact- N(11)<br>2° Contact- N(11)<br>Aesthetics- N(11) | Noxious plants |
| **Crystal Lake Douglas** | **MA51031** | 90 | E | 1° Contact- N(70);U(20)<br>2° Contact- N(70);U(20)<br>Aesthetics- N(70);U(20) | Noxious plants |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana*, **Mh**=*Myriophyllum heterophyllum*, **Ms**=*Myriophyllum spicatum*, **Nm**=*Najas minor*

**Use Assessment: Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| **Curtis Pond, {north basin} Worcester** | **MA51032** | 36 | E | ALUS- P(36)<br>1° Contact- N(10);U(26)<br>2° Contact- N(10);U(26)<br>Aesthetics- N(10);U(26) | Noxious plants<br>Non-native plants (Cc) |
| **Curtis Pond, {south basin} Worcester** | **MA51033** | 18 | E (10)<br>Not applicable (8) | ALUS- U(10);NA(8)<br>Fish Consumption- U(10);NA(8)<br>1° Contact- N(10);NA(8)<br>2° Contact- N(10);NA(8)<br>Aesthetics- N(10);NA(8) | Noxious plants<br>Siltation |
| **Dark Brook Pond, Sutton** | **MA51034** | 21 | E | 1° Contact- N(21)<br>2° Contact- N(21)<br>Aesthetics- N(21) | Noxious plants |
| **Dark Brook Reservoir {north basin}, Auburn** | **MA51036** | 256 | E | ALUS- P(256)<br>2° Contact- S(256)<br>Aesthetics- S(256) | Non-native plants (Ms) |
| Dark Brook Reservoir {south basin}, Aubum | MA51035 | 57 | E | ALUS- P(57)<br>1° Contact- N(17);U(40)<br>2° Contact- S(40);N(17)<br>Aesthetics- S(40);N(17) | Noxious plants<br>Non-native plants (Ms, Nm) |
| Doctors Pond, Uxbridge | **MA51194** | 1 | E | 1° Contact- N(1)<br>2° Contact- N(1)<br>Aesthetics- N(1) | Noxious plants |
| **Dorothy Pond, Millbury** | **MA51039** | 148 | E | ALUS- P(148) | Non-native plants (Ms, Nm) |
| **Dudley Pond, Douglas** | **MA51041** | 7 | E | 1° Contact- N(4);U(3)<br>2° Contact- N(4);U(3)<br>Aesthetics- N(4);U(3) | Noxious plants |
| **Eddy Pond, Auburn** | **MA51043** | 134 | E | ALUS- P(134)<br>1° Contact- N(99);U(35)<br>2° Contact- S(35); N(99)<br>Aesthetics- S(35);N(99) | Noxious plants<br>Non-native plants (Mh) |
| **Fish Pond, Northbridge** | **MA51047** | 8 | E | ALUS- P(8)<br>1° Contact- N(8)<br>2° Contact- N(8)<br>Aesthetics- N(8) | Noxious plants<br>Non-native plants (Cc, Mh) |
| **Fiske Millpond, Upton/Milford** | **MA51049** | 16 | E | ALUS- P(16)<br>1° Contact- N(3);U(13)<br>2° Contact- N(3);U(13)<br>Aesthetics- N(3);U(13) | Noxious plants<br>Non-native plants (Mh) |
| **Flint Pond, {north basin} Worcester/Grafton/ Shrewsbury** | **MA51050** | 84 | E | ALUS- P(84)<br>1° Contact- N(45); U(39)<br>2° Contact- S(39);N(45)<br>Aesthetics- S(39);N(45) | Noxious plants<br>Non-native plants (Cc, Ms) |
| Flint Pond, {south basin} Worcester/Shrewsbury | MA51188 | 170 | E | ALUS- P(170)<br>1° Contact- N(87);U(83)<br>2° Contact- S(83);N(87)<br>Aesthetics- S(83);N(87) | Noxious plants<br>Non-native plants (Cc, Mh, Ms) |
| Forge Pond, Blackstone | MA51051 | 15 | Not applicable | ALUS- NA(15)<br>Fish Consumption- NA(15)<br>1° Contact- NA(15)<br>2° Contact- NA(15)<br>Aesthetics- NA(15) | Flow alteration |
| **Gilboa Pond, Douglas** | **MA51052** | 21 | E | ALUS- P(21)<br>1° Contact- N(7);U(14)<br>2° Contact- N(7);U(14)<br>Aesthetics- N(7);U(14) | Noxious plants<br>Non-native plants (Mh) |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana,* ***Mh****=Myriophyllum heterophyllum,* **Ms**=*Myriophyllum spicatum,* **Nm**=*Najas minor*

**Use Assessment**: **Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| Girard Pond, Sutton | MA51053 | 2 | E | ALUS- P(2) | Non-native plants (Cc) |
| Harrington Pool (West Hill Dam Impoundment), Uxbridge | MA51197 | 1 | U | 2° Contact- S(1)<br>Aesthetics- S(1) | |
| **Harris Pond, Blackstone** | **MA51058** | 93 | E | ALUS- P(93)<br>2° Contact- S(73);U(20)<br>Aesthetics- S(73);U(20) | Non-native plants (Cc) |
| **Hathaway Pond, Millbury/ Sutton** | **MA51059** | 10 | E | 1° Contact- N(10)<br>2° Contact- N(10)<br>Aesthetics- N(10) | Noxious plants |
| **Hayes Pond, Grafton** | **MA51060** | 6 | H | ALUS- P(6)<br>1° Contact- P(3);N(3)<br>2° Contact- P(3);N(3)<br>Aesthetics- P(3);N(3) | Noxious plants<br>Non-native plants (Cc) |
| Holden Reservoir 1 * Holden | MA51063 | 119 | U | 2° Contact- S(119)<br>Aesthetics- S(119) | |
| Holden Reservoir 2 * Holden | MA51064 | 46 | U | 2° Contact- S(46)<br>Aesthetics- S(46) | |
| **Hopedale Pond, Hopedale** | **MA51065** | 95 | E | ALUS- P(95)<br>1° Contact- P(22);N(73)<br>2° Contact- P(22);N(73)<br>Aesthetics- P(22);N(73) | Noxious plants<br>Non-native plants (Cc, Mh) |
| **Hovey Pond, Grafton** | **MA51068** | 19 | E | ALUS- P(19)<br>1° Contact- N(10);U(9)<br>2° Contact- N(10);U(9)<br>Aesthetics- N(10);U(9) | Noxious plants<br>Non-native plants (Cc, Ms) |
| **Howe Pond, Millbury** | **MA51069** | 6 | E | 1° Contact- P(6)<br>2° Contact- P(6)<br>Aesthetics- P(6) | Noxious plants |
| **Howe Reservoir {east basin}, Millbury** | **MA51070** | 3 | E | ALUS- P(1);N(2)<br>1° Contact- N(3)<br>2° Contact- N(3)<br>Aesthetics- N(3) | Flow alteration<br>Noxious plants<br>Non-native plants (Mh) |
| **Howe Reservoir {west basin}, Millbury** | **MA51071** | 13 | M | 1° Contact- N(8);U(5)<br>2° Contact- N(8);U(5)<br>Aesthetics- N(8);U(5) | Noxious plants |
| **Indian Lake, Worcester** | **MA51073** | 193 | E | 1° Contact- P(193)<br>2° Contact- P(193)<br>Aesthetics- P(193) | Noxious plants |
| **Ironstone Reservoir, Uxbridge** | **MA51074** | 26 | E | ALUS- P(26)<br>1° Contact- N(19);U(7)<br>2° Contact- S(7);N(19)<br>Aesthetics- S(7);N(19) | Noxious plants<br>Non-native plants (Cc) |
| **Jenks Reservoir, Bellingham** | **MA51075** | 27 | E | ALUS- P(27)<br>1° Contact- N(21);U(6)<br>2° Contact- S(6);N(21)<br>Aesthetics- S(6);N(21) | Noxious plants<br>Non-native plants (Mh) |
| **Joes Rock Pond, Wrentham** | **MA51077** | 12 | E | 1° Contact- N(12)<br>2° Contact- N(12)<br>Aesthetics- N(12) | Noxious plants |
| Kettle Brook Reservoir 1 * Leicester | MA51079 | 11 | M | 2° Contact- S(11)<br>Aesthetics- S(11) | |
| Kettle Brook Reservoir 2 * Leicester | MA51080 | 29 | O | 2° Contact- S(29)<br>Aesthetics- S(29) | |

* Indicates Class A (water supply) waterbody; all others are Class B.
** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).
**WBID** – Waterbody Identification Code
**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.
**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana*, ***Mh***=*Myriophyllum heterophyllum*, **Ms**=*Myriophyllum spicatum*, **Nm**=*Najas minor*
**Use Assessment**: **Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| Kettle Brook Reservoir 3 * Paxton | MA51081 | 37 | O | 2° Contact- S(37)<br>Aesthetics- S(37) | |
| Kettle Brook Reservoir 4 * Paxton | MA51082 | 119 | O | 2° Contact- S(119)<br>Aesthetics- S(119) | |
| Lackey Pond, Uxbridge/ Sutton | MA51083 | 117 | U | 1° Contact- N(73);U(44)<br>2° Contact- S(44);N(73)<br>Aesthetics- S(44);N(73) | Flow alteration<br>Noxious plants |
| **Lake Quinsigamond Shrewsbury/ Worcester** | **MA51125** | 475 | M | ALUS- P(170);U(305)<br>1° Contact- N(20); U(455)<br>2° Contact- N(20); U(455)<br>Aesthetics- N(20); U(455) | Noxious plants<br>Non-native plants (Cc, Mh, Ms, Pc) |
| **Lake Ripple, Grafton** | **MA51135** | 63 | H | ALUS- P(63)<br>2° Contact- S(63)<br>Aesthetics- S(63) | Non-native plants (Cc,Mh) |
| **Lee Reservoir, Uxbridge** | **MA51086** | 9 | M | 1° Contact- P(2);U(7)<br>2° Contact- P(2);U(7)<br>Aesthetics- P(2);U(7) | Noxious plants |
| **Leesville Pond, Auburn/ Worcester** | **MA51087** | 96 | H | ALUS- N(96)<br>1° Contact- N(96)<br>2° Contact- N(96)<br>Aesthetics- N(96) | Nutrients<br>Non-native plants (Cc) |
| Linwood Pond, Northbridge | MA51088 | 61 | E | ALUS- P(61)<br>1° Contact- N(14);U(47)<br>2° Contact- S(47);N(14)<br>Aesthetics- S(47);N(14) | Noxious plants<br>Non-native plants (Cc) |
| Lynde Brook Reservoir * Leicester | MA51090 | 132 | O | 2° Contact- S(132)<br>Aesthetics- S(132) | |
| **Manchaug Pond, Douglas/ Sutton** | **MA51091** | 348 | M | ALUS- P(348)<br>1° Contact- P(40); U(308)<br>2° Contact- S(308); P(40)<br>Aesthetics- S(308);P(40) | Noxious plants<br>Non-native plants (Cc, Mh. Pc) |
| **Marble Pond, Sutton** | **MA51093** | 11 | E | ALUS- P(11)<br>1° Contact- N(11)<br>2° Contact- N(11)<br>Aesthetics- N(11) | Noxious plants<br>Non-native plants (Mh) |
| **Martin Street Pond, Douglas** | **MA51095** | 7 | E | 1° Contact- N(4);U(3)<br>2° Contact- N(4);U(3)<br>Aesthetics- N(4);U(3) | Noxious plants |
| Mayo Pond, Millbury | MA51096 | 8 | Not applicable | ALUS- NA (8)<br>Fish Consumption- NA(8)<br>1° Contact- NA(8)<br>2° Contact- NA(8)<br>Aesthetics- NA(8) | Flow alteration |
| **Meadow Pond, Sutton/ Northbridge** | **MA51193** | 45 | E | ALUS- P(45)<br>2° Contact- S(45)<br>Aesthetics- S(45) | Non-native plants (Cc) |
| **Merrill Pond, No. 3, Sutton** | **MA51098** | 15 | E | 1° Contact- N(5);U(10)<br>2° Contact- N(5);U(10)<br>Aesthetics- N(5);U(10) | Noxious plants |
| **Merrill Pond, No. 4, Sutton** | **MA51099** | 19 | E | 1° Contact- N(19)<br>2° Contact- N(19)<br>Aesthetics- N(19) | Noxious plants |

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** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana*, ***Mh***=*Myriophyllum heterophyllum*, **Ms**=*Myriophyllum spicatum*, **Nm**=*Najas minor*

**Use Assessment**: **Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| Merrill Pond No. 6, Sutton | MA51100 | 18 | Not applicable | ALUS- NA(18)<br>Fish Consumption- NA(18)<br>1° Contact- NA(18)<br>2° Contact- NA(18)<br>Aesthetics- NA(18) | Flow alteration |
| Middle River Pond, Worcester | MA51101 | 16 | Not applicable | ALUS- NA(16)<br>Fish Consumption- NA(16)<br>1° Contact- NA(16)<br>2° Contact- NA(16)<br>Aesthetics- NA(16) | Flow alteration |
| **Milford Street Pond, Hopedale/ Milford** | **MA51102** | 17 | E | 1° Contact- N(17)<br>2° Contact- N(17)<br>Aesthetics- N(17) | Noxious plants |
| **Mill Pond, Upton** | **MA51104** | 9 | H | ALUS- N(9)<br>1° Contact- N(9)<br>2° Contact- N(9)<br>Aesthetics- N(9) | Noxious plants<br>Non-native plants (Cc,Mh) |
| **Miscoe Lake **, Wrentham/ Cumberland, RI** | **MA51106** | 43 | E | ALUS- P(43)<br>1° Contact- N(25);U(18)<br>2° Contact- N(25);U(18)<br>Aesthetics- N(25);U(18) | Noxious plants<br>Non-native plants (Cc,Mh) |
| **Newton Pond, Shrewsbury/ Boylston** | **MA51110** | 48 | M | ALUS- P(48)<br>1° Contact- N(7);U(41)<br>2° Contact- S(41);N(7)<br>Aesthetics- S(41);N(7) | Noxious plants<br>Non-native plants (Cc,Mh) |
| North Pond, Hopkinton/ Milford | MA51112 | 238.6 | E | ALUS- P(238.6)<br>1° Contact- P(180); U(58.6)<br>2° Contact- P(180); U(58.6)<br>Aesthetics- P(180); U(58.6) | Noxious plants<br>Non-native plants (Cc,Mh) |
| **Number 1 Pond, Sutton** | **MA51114** | 10 | E | 1° Contact- N(2);U(8)<br>2° Contact- N(2);U(8)<br>Aesthetics- N(2);U(8) | Noxious plants |
| **Number 2 Pond, Sutton** | **MA51115** | 9 | E | 1° Contact- N(2);U(7)<br>2° Contact- N(2);U(7)<br>Aesthetics- N(2);U(7) | Noxious plants |
| Patch Reservoir, Worcester | MA51118 | 31 | E | 2° Contact- S(31)<br>Aesthetics- S(31) | |
| **Peabody Pond, Uxbridge** | **MA51119** | 11 | E | 1° Contact- N(5);U(6)<br>2° Contact- N(5);U(6)<br>Aesthetics- N(5);U(6) | Noxious plants |
| **Pondville Pond, Auburn** | **MA51120** | 41 | E | ALUS- N(41)<br>1° Contact- N(41)<br>2° Contact- N(41)<br>Aesthetics- N(41) | Noxious plants<br>Non-native plants (Cc) |
| **Pout Pond, Boylston** | **MA51122** | 13 | E | 1° Contact- N(13)<br>2° Contact- N(13)<br>Aesthetics- N(13) | Noxious plants |
| **Pratt Pond, Upton** | **MA51123** | 38 | E | ALUS- P(38)<br>1° Contact- N(4);U(34)<br>2° Contact- S(34);N(4)<br>Aesthetics- S(34);N(4) | Noxious plants<br>Non-native plants (Cc,Mh) |
| **Pratts Pond, Grafton** | **MA51124** | 6 | M | 1° Contact- N(2);U(4)<br>2° Contact- N(2);U(4)<br>Aesthetics- N(2);U(4) | Noxious plants |
| Reservoir No. 4, Sutton | MA51128 | 10 | U | 2° Contact- S(10)<br>Aesthetics- S(10) | |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State:** D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants:**Cc=*Cabomba caroliniana,* ***Mh****=Myriophyllum heterophyllum,* **Ms**=*Myriophyllum spicatum,* **Nm**=*Najas minor*

**Use Assessment: Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| **Rice City Pond, Uxbridge** | **MA51131** | 91 | E (10)<br>Not applicable (81) | ALUS- U(10);NA(81)<br>Fish Consumption- N(10);NA(81)<br>1° Contact- U(10); NA(81)<br>2° Contact- U(10); NA(81)<br>Aesthetics- U(10); NA(81) | Priority organics (PCB)<br>Siltation |
| **Riverdale Pond, Northbridge** | **MA51136** | 18 | E | Fish Consumption- N(18) | Priority organics (PCB) |
| Riverlin Street Pond, Millbury | MA51137 | 7 | E | ALUS- N(7)<br>1° Contact- N(7)<br>2° Contact- N(7)<br>Aesthetics- N(7) | Non-native plants (Mh) |
| **Rivulet Pond, Uxbridge** | **MA51138** | 9 | E | ALUS- P(9)<br>1° Contact- N(7);U(2)<br>2° Contact- N(7);U(2)<br>Aesthetics- N(7);U(2) | Noxious plants<br>Non-native plants (Mh) |
| **Salisbury Pond, Worcester** | **MA51142** | 18 | H | 1° Contact- P(18)<br>2° Contact- P(18)<br>Aesthetics- P(18) | Turbidity<br>Taste, odor, color |
| **Schoolhouse Pond, Sutton** | **MA51144** | 6 | E | 1° Contact- N(5);U(1)<br>2° Contact- N(5);U(1)<br>Aesthetics- N(5);U(1) | Noxious plants |
| **Sewall Pond, Boylston** | **MA51191** | 11 | M | 1° Contact- P(1);U(10)<br>2° Contact- P(1);U(10)<br>Aesthetics- P(1);U(10) | Noxious plants |
| **Shirley Street Pond, Shrewsbury** | **MA51196** | 17 | E | 1° Contact- N(15);U(2)<br>2° Contact- N(15);U(2)<br>Aesthetics- N(15);U(2) | Noxious plants |
| Sibley Reservoir, Sutton | MA51148 | 37 | U (22)<br>Not applicable (15) | ALUS- U(22);NA(15)<br>Fish Consumption- U(22);NA(15)<br>1° Contact- U(22); NA(15)<br>2° Contact- U(22); NA(15).<br>Aesthetics- U(22); NA(15) | Flow alteration |
| **Silver Hill Pond, Milford** | **MA51149** | 8 | E | 1° Contact- N(8)<br>2° Contact- N(8)<br>Aesthetics- N(8) | Noxious plants |
| **Silver Lake, Bellingham** | **MA51150** | 70 | M | 1° Contact- N(17);U(53)<br>2° Contact- S(53);N(17)<br>Aesthetics- S(53);N(17) | Noxious plants |
| **Silver Lake, Grafton** | **MA51151** | 23 | E | 1° Contact- N(5);U(18)<br>2° Contact- N(5);U(18)<br>Aesthetics- N(5);U(18) | Flow alteration |
| Singletary Pond, Sutton/ Millbury | MA51152 | 330 | M | ALUS-P(330)<br>2° Contact- S(330)<br>Aesthetics- S(330) | Non-native plants (Ms) |
| **Slaughterhouse Pond, Sutton** | **MA51153** | 8 | E | 1° Contact- N(8)<br>2° Contact- N(8)<br>Aesthetics- N(8) | Noxious plants |
| **Smiths Pond, Leicester** | **MA51156** | 20 | H | 1° Contact- P(20)<br>2° Contact- P(20)<br>Aesthetics- P(20) | Turbidity |
| **Southwick Pond **, Leicester/ Paxton** | **MA51157** | 36 | E | 1° Contact- N(36)<br>2° Contact- N(36)<br>Aesthetics- N(36) | Noxious plants |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana,* ***Mh****=Myriophyllum heterophyllum,* **Ms**=*Myriophyllum spicatum,* **Nm**=*Najas minor*

**Use Assessment**: **Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| **Spindleville Pond, Hopedale** | **MA51158** | 12 | H | Fish Consumption- N(12)<br>1° Contact- N(12)<br>2° Contact- N(12)<br>Aesthetics- N(12) | Priority organics (PCB)<br>Noxious plants |
| Stevens Pond, Sutton | MA51159 | 84 | M | ALUS- P(84) | Non-native plants (Cc) |
| **Stoneville Pond, Auburn** | **MA51160** | 43 | H | ALUS- P(43)<br>1° Contact- N(30);U(13)<br>2° Contact- S(13);N(30)<br>Aesthetics- S(13);N(30) | Noxious plants<br>Non-native plants (Cc) |
| Stoneville Reservoir, Auburn | MA51161 | 61 | M | 2° Contact- S(61)<br>Aesthetics- S(61) | |
| **Swans Pond, Sutton** | **MA51164** | 31 | E | ALUS- P(31)<br>1° Contact- N(31)<br>2° Contact- N(31)<br>Aesthetics- N(31) | Noxious plants<br>Non-native plants (Mh) |
| **Taft Pond, Upton** | **MA51165** | 12 | M | 1° Contact- P(4);U(8)<br>2° Contact- P(4);U(8)<br>Aesthetics- P(4);U(8) | Noxious plants |
| Thompson Pond, Sutton | MA51166 | 8 | Not applicable | ALUS- NA(8)<br>Fish Consumption- NA(8)<br>1° Contact- NA(8)<br>2° Contact- NA(8)<br>Aesthetics- NA(8) | Flow alteration |
| Tinker Hill Pond, Auburn | MA51167 | 37 | E | ALUS- P(37)<br>1° Contact- N(37)<br>2° Contact- N(37)<br>Aesthetics- N(37) | Noxious plants<br>Non-native plants (Mh,Nm) |
| **Town Farm Pond, Sutton** | **MA51168** | 7 | M | 1° Contact- P(1);U(6)<br>2° Contact- P(1);U(6)<br>Aesthetics- P(1);U(6) | Noxious plants |
| **Tuckers Pond, Sutton** | **MA51169** | 28 | U | ALUS- P(28)<br>1° Contact- N(7);U(21)<br>2° Contact- S(21);N(7)<br>Aesthetics- S(21);N(7) | Noxious plants<br>Non-native plants (Mh) |
| Waite Pond, Leicester | MA51170 | 54 | M | Fish Consumption- N(54)<br>2° Contact- S(54)<br>Aesthetics- S(54) | Metals (Hg) |
| **Welsh Pond, Sutton** | **MA51176** | 8 | H | ALUS- P(8)<br>1° Contact- N(8)<br>2° Contact- N(8)<br>Aesthetics- N(8) | Noxious plants<br>Non-native plants (Mh) |
| **West River Pond, Uxbridge** | **MA51177** | 37 | E | ALUS- P(37)<br>1° Contact- N(19);U(18)<br>2° Contact- N(19);U(18)<br>Aesthetics- N(19);U(18) | Noxious plants<br>Non-native plants (Cc) |
| Whitin Pond, Uxbridge | MA51178 | 23 | E | ALUS- P(23)<br>1° Contact- N(20);U(3)<br>2° Contact- S(3);N(20)<br>Aesthetics- S(3);N(20) | Noxious plants<br>Non-native plants (Cc) |
| **Whitins Pond, Northbridge/ Sutton** | **MA51180** | 167 | M | ALUS- P(167)<br>1° Contact- N(15);U(152)<br>2° Contact- S(152);N(15)<br>Aesthetics- S(152);N(15) | Noxious plants<br>Non-native plants (Cc) |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State**: D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana*, ***Mh***=*Myriophyllum heterophyllum*, **Ms**=*Myriophyllum spicatum*, **Nm**=*Najas minor*

**Use Assessment: Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 5. Continued. Blackstone River Basin lake assessments (**Bold indicates 1998 303(d) listed**).

| LAKE | WBID | SIZE Acres | TROPHIC STATE | USE ASSESSMENT (Acres) | IMPAIRMENT CAUSE(S) |
|---|---|---|---|---|---|
| **Wildwood Lake, Upton/ Grafton** | **MA51181** | 38 | E | ALUS- P(38)<br>1° Contact- N(16);U(22)<br>2° Contact- S(22);N(16)<br>Aesthetics- S(22);N(16) | Noxious plants<br>Non-native plants<br>(Cc) |
| Williams Street Pond, Upton | MA51183 | 5 | Not applicable | ALUS- NA(5)<br>Fish Consumption- NA(5)<br>1° Contact- NA(5)<br>2° Contact- NA(5)<br>Aesthetics- NA(5) | Flow alteration |
| **Windle Pond, Grafton/ Shrewsbury** | **MA51184** | 5 | E | 1° Contact- N(2);U(3)<br>2° Contact- N(2);U(3)<br>Aesthetics- N(2);U(3) | Noxious plants |
| **Woodbury Pond, Sutton** | **MA51185** | 7 | E | ALUS- P(7)<br>1° Contact- N(7)<br>2° Contact- N(7)<br>Aesthetics- N(7) | Noxious plants<br>Non-native plants<br>(Cc, Mh) |
| **Woolshop Pond, Millbury** | **MA51186** | 8 | H | ALUS- P(8)<br>1° Contact- N(6);U(2)<br>2° Contact- N(6);U(2)<br>Aesthetics- N(6);U(2) | Noxious plants<br>Non-native plants<br>(Pc) |

* Indicates Class A (water supply) waterbody; all others are Class B.

** Indicates special case Class A (water supply) waterbody designation "Interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State:** D = dystrophic, **E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined.

**Non-native Aquatic Plants**:Cc=*Cabomba caroliniana,* ***Mh****=Myriophyllum heterophyllum,* **Ms**=*Myriophyllum spicatum,* **Nm**=*Najas minor*

**Use Assessment**: **Uses** (Aquatic Life - ALUS, Fish Consumption, Primary Contact Recreational - 1° Contact, Secondary Contact Recreational - 2° Contact, Aesthetics), **Status** (**S** = support, **T** = threatened, **P** = partial support, **N** = non-support, **NA** = not attainable, **U** = undetermined/not assessed)

Table 6. Blackstone River Basin lakes in the DWM/EPA Waterbody System database but not assessed during the 1998 assessment cycle (**Bold indicates 1998 303(d) listed lakes**).

| LAKE, LOCATION | WBID | SIZE (Acres) | TROPHIC STATE |
|---|---|---|---|
| Bazely Pond, Uxbridge | MA51008 | 3 | M |
| Bell Pond, Worcester | MA51009 | 7 | M |
| **Burncoat Park Pond, Worcester** | **MA51012** | 5 | H |
| Chockalog Pond, Uxbridge | MA51018 | 11 | M |
| City Pond, Leicester | MA51021 | 5 | E |
| Fisherville Pond, Grafton | MA51048 | 57 | U |
| **Green Hill Pond, Worcester** | **MA51056** | 32 | E |
| Hales Pond, Wrentham | MA51057 | 5 | E |
| Lake Hiawatha, Bellingham/Blackstone | MA51062 | 63 | M |
| Houghton Pond, Uxbridge | MA51067 | 2 | M |
| Hunt Pond, Douglas | MA51072 | 2 | M |
| Joels Pond, Uxbridge | MA51076 | 14 | M |
| **Jordan Pond, Shrewsbury** | **MA51078** | 20 | E |
| **Mill Pond, Shrewsbury** | **MA51105** | 16 | E |
| Nipmuck Pond, Mendon | MA51111 | 85 | M |
| Pout Pond, Uxbridge | MA51121 | 9 | M |
| Ramshorn Pond, Sutton/Millbury | MA51126 | 117 | U |
| **Riley Pond, Northbridge** | **MA51134** | 8 | E |
| Stump Pond, Oxford | MA51162 | 18 | M |
| **Sutton Falls, Sutton** | **MA51163** | 9 | E |
| Wallum Lake*, Douglas/Burrillville RI | MA51172 | 322 | O |
| Whitin Reservoir, Douglas | MA51179 | 309 | M |

All lakes in this table are Class B except Wallum Lake, which is especial case Class A (water supply) waterbody. This designation applies to "interstate surface waters that are public water supply in Rhode Island from 1000 feet upstream of the State Line" (MA DEP 1996).

**WBID** – Waterbody Identification Code

**Trophic State: E** = eutrophic, **H** = hypereutrophic, **M** = mesotrophic, **O** = oligotrophic, **U** = undetermined

**RECOMMENDATIONS – LAKES**

- Coordinate with DEM and/or other groups conducting lake surveys to generate quality assured lakes data. Conduct more intensive lake surveys to better determine the lake trophic and use support status and identify causes and sources of impairment. As sources are identified within lake watersheds, they should be eliminated or, at least minimized through the application of appropriate point or non-point source control techniques.

- For non-native aquatic or wetland plant species that are isolated to one or a few location(s), quick action is advisable to manage these populations in order to alleviate the need for costly and potentially fruitless efforts to do so in the future. Two courses of action should be pursued concurrently. More extensive surveys need to be conducted, particularly downstream from these recorded locations (Table 5), to determine the extent of the infestation. And, "spot" treatments (refer to the draft Generic Environmental Impact Report for Eutrophication and Aquatic Plant Management in Massachusetts [MA DEP and DEM 1998] for advantages and disadvantages) should be undertaken to control populations at these sites before they spread further. These treatments may be in the form of carefully hand-pulling individual plants in small areas. In larger areas, other techniques such as selective herbicide application may be necessary. In either case, the treatments should be undertaken prior to fruit formation and with a minimum of fragmentation of the individual plants. These cautions will minimize the spreading of the populations. This draft aquatic plant report (MA DEP and DEM 1998) should be consulted prior to the development of any lake management plan to control non-native aquatic or wetland plant species.

- As with the isolated cases, a program to manage the more extensive plant infestations should include additional monitoring efforts to determine the extent of the problem. The draft Generic Environmental Impact Report for Eutrophication and Aquatic Plant Management in Massachusetts (MA DEP and DEM 1998) should be consulted prior to the development of any lake management plan to control non-native aquatic plant species. Plant control options can be selected from several techniques (e.g., bottom barriers, drawdown, herbicides, etc.) each of which has advantages and disadvantages that need to be addressed for the specific site. However, methods that result in fragmentation (such as cutting or raking) should be discouraged because of the propensity for these plants to reproduce and spread vegetatively (from cuttings).

- Confirm the presence of *Myriophyllum heterophyllum* in the following 12 lakes: Caprons Pond (Uxbridge), Eddy Pond (Auburn), Ironstone Reservoir (Uxbridge), Jenks Reservoir (Bellingham), Pratt Reservoir (Worcester), Silver Lake (Grafton), Tinker Hill Pond (Auburn), Wildwood Lake (Upton/Grafton), Lake Ripple (Grafton), Whitins Pond (Northbridge/Sutton), Manchaug Pond, (Douglas/Sutton), and Waite Pond (Leicester).

- Another important component of a management plan is prevention of further spreading of these plants. Once the extent of the problem is determined and control practices are exercised, vigilant monitoring needs to be practiced to guard against infestations occurring in unaffected areas and to ensure that managed areas stay in check. A key portion of the prevention program should be posting of boat access points with signs to educate and alert lake-users to the problem and responsibility of spreading these species.

- Implement recommendations identified in the TMDLs and lake Diagnostic/Feasibility studies, including lake watershed surveys to identify sources of impairment.

- Investigate the downstream spread of non-native aquatic plant species in the following lakes:
  ***Cabomba caroliniana* (Fanwort):**
  Mud Pond, Brooklawn Parkway Pond, Shirley Street Pond (Shrewsbury), Lake Quinsigamond (Shrewsbury/Worcester), Hovey Pond, Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge), Patch Reservoir, Coes Reservoir (Worcester), Leesville Pond (Auburn/Worcester), Curtis Pond north and south basins (Worcester), Stevens Pond (Sutton), Gilboa Pond (Douglas), Lackey Pond (Uxbridge/Sutton), Williams Street Pond (Upton), and Spindleville Pond (Hopedale).
  ***Myriophyllum heterophyllum* (Variable water milfoil):**
  Mud Pond, Brooklawn Parkway Pond, Shirley Street Pond (Shrewsbury), Lake Quinsigamond (Shrewsbury/Worcester), Flint Pond north basin (Shrewsbury), Hovey Pond, Lake Ripple, Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge), Gilboa Pond (Douglas), Lackey Pond (Uxbridge/Sutton), Meadow Pond (Sutton/Northbridge), Linwood Pond (Northbridge), Whitin Pond, Caprons Pond (Uxbridge), Spindleville Pond (Hopedale), and Harris Pond (Blackstone).
  ***Myriophyllum spicatum* (Eurasian water milfoil):**
  Hovey Pond, Lake Ripple, Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge), Fisherville Pond (Grafton), Rice City Pond (Northbridge/Uxbridge), Stoneville Pond (Auburn), Leesville Pond (Auburn/Worcester), Curtis Pond north and south basins (Worcester), and Brierly Pond (Millbury).
  ***Najas minor* (Bushy pondweed):**
  Dark Brook Reservoir north basin, Stoneville Pond (Auburn), Leesville Pond (Auburn/Worcester) Curtis Pond north and south basins (Worcester), Fisherville Pond (Grafton), and Rice City Pond (Northbridge/Uxbridge).

- Continue to support community efforts to eradicate invasive species:
  Lake Wildwood, Upton is an impoundment with many shallow areas and dense beds of aquatic vegetation, including the invasive exotic species fanwort (*Cabomba caroliniana*). The town of Upton is currently funding an aggressive aquatic plant species control program (Beaudoin 2001).

- Review data from "Beaches Bill" required water quality testing (bacteria sampling from all formal bathing beaches) to assess the status of the recreational uses; e.g. Silver Lake beach, Grafton, and others.

- Review the DEP Drinking Water Program SWAP evaluations are when they are completed to develop and implement recommendations for the protection of Class A lakes in the Blackstone River Basin including Holden Reservoirs #1 and 2, Kettle Brook Reservoirs #1-4, Lynde Brook Reservoir, Miscoe and Wallum lakes, and Southwick Pond.

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# APPENDIX A – 1998 DEP DWM BLACKSTONE RIVER BASIN QA/QC REPORT

## INTRODUCTION

Quality Assurance/Quality Control (QA/QC) activities were conducted as part of the DEP DWM Blackstone River Watershed Monitoring Survey in 1998. This included production of a Quality Assurance Project Plan (MA DEP 1999a), implementation of field and lab quality control procedures, and post-monitoring data review and validation. The post-monitoring data review and validation was conducted to ensure that the collection and analysis of the monitoring data followed approved standard operating procedures (SOPs) and that data collected met project data quality objectives (DQO's) contained in the Quality Assurance Project Plan (QAPP).

The 1998 monitoring data for the Blackstone River includes the following: discrete (grab) water samples, *in-situ* water quality measurements and fish tissue samples. All discrete water sample and fish tissue monitoring data were reviewed independently by the Wall Experiment Station's (WES) Quality Assurance Program, the Division of Watershed Management's (DWM) Quality Control Officer, Assessment Coordinator, and the DWM Database Manager. All *in-situ* water quality measurements were reviewed independently by DWM's Hydrolab® Multiprobe Series 3 analyzer (hereafter referred to as Hydrolab®) Instrument Coordinator and Database Manager. Data that fell outside established QA/QC acceptance criteria were investigated and may have been subject to censoring.

The QA/QC Appendix is divided into five sections: Introduction, Field and Laboratory QA/QC Objectives, Criteria and Procedures; QA/QC Data Validation, Analytical Methods, and Conclusions.

## A.1 FIELD AND LABORATORY QA/QC OBJECTIVES

Data collected by DWM in the 1998 Blackstone River survey was reviewed for conformance to field and laboratory data quality objectives. Section A.1.1 outlines the field collection objectives and laboratory quality control for discrete water samples. Section A.1.2 includes fish tissue laboratory quality control methods and Section A.1.3 includes Hydrolab® QA/QC procedures.

### A.1.1 Discrete Water Sample Data

***FIELD***

Note: A more detailed QA/QC assessment for the 1998 Blackstone River Watershed data can be found in a DWM annual report, the 1998 QA/QC Assessment Report (MA DEP 2000a).

The collection of discrete water sample analytes followed DWM Standard Operating Procedure, CN 1.0 (MA DEP 1999b). Four field collection quality control criteria were applied to the Blackstone River Watershed 1998 discrete water sample data. Using these criteria as well as other considerations and input from data reviewers, data were accepted or censored.

1) Sampling/Analysis Holding Time: Each analyte has a standard holding time that has been established to ensure sample/analysis integrity. Refer to DWM Standard Operating Procedure CN# 1.0 (MA DEP 1999b) for a complete listing. If the standard holding time was exceeded, this criterion is violated and the data may be censored, depending on the extent of exceedance.

2) Quality Control Sample Frequency: At a minimum, one field blank and one replicate must be collected for every ten samples by any given sampling crew on any given date. If less than 10% was collected for blanks and/or replicates, this criterion is violated and the data may be censored.

3) Field Blank: Field blanks were prepared at the DWM Worcester Laboratory. Reagent grade water was transported into the field in a sample container where it was transferred into a different sample container and fixed where necessary using the same method as its corresponding field sample. All blanks were submitted to the WES laboratory "blind". If the field blanks were

significantly different (>2 standard deviations (Clesceri *et al.* 1998)) from the detection limit, this criterion is violated and the data may be censored.

4) Field Replicates: Two independent samples were collected from the same location and as close as possible to the same time in the field (i.e., sequential duplicates or co-located duplicates, if possible). Both samples were submitted to WES laboratory "blind". In order for this data quality criterion to be met, the results must be:

- <20% Relative Percent Difference (RPD) for method detection limits >1mg/L or
- <30% RPD for method detection limits <1mg/L.

If this criterion is violated, the data may be censored.

***LABORATORY***

Analysis of discrete samples followed EPA-approved laboratory QA/QC methodologies in accordance with WES Standard Operating Procedures (MA DEP 1995). The QA/QC procedures used to ensure acceptance of lab data included:

1) Low Calibration Standards – Checks the stability of the instrument's calibration curve. Analyzes the *accuracy* of an instrument's calibration within a 5% range.

2) Reference Standards – Generally, a second source standard (a standard different from the calibration stock standard) that analyzes the method *accuracy*.

3) Laboratory Reagent Blank/Method Blank (LRB) – Reagent grade water (de-ionized) extracted with every sample set used to ensure that the system is free of target analytes (< MDL) and to assess potential blank contamination.

4) Duplicate Sample – Measures the *precision* (as Relative Percent Difference or RPD) of the analytical process. The acceptable laboratory %RPD range is typically ≤ 25%.

5) Spike Sample (Laboratory Fortified Blank - LFB, Laboratory Fortified Matrix - LFM)– Measures the *accuracy* (% Recovery) of an analytical method. The acceptable laboratory % recovery range is typically between 80 – 120% for LFB samples and 70 –130% for LFM discrete water samples.

The WES Laboratory is solely responsible for the administration of its Quality Assurance Program and Standard Operating Procedures. Refer to WES's Quality Assurance Plan (MA DEP 1995) for specific laboratory analytical QA/QC criteria. WES laboratory releases discrete water sample data when their established QA/QC criteria are met. When criteria can not be met (even upon re-analysis), data are qualified as "estimated" ("J") if appropriate, or no data ("ND") is reported.

### A.1.2 Fish Tissue Data

Fish were collected and processed according to DWM's Quality Assurance Project Plan (MA DEP 1999c) and a modified version of the SOP for Fish Toxics Monitoring (MA DEP 1990). These documents adhere to EPA-approved laboratory QA/QC methodologies (EPA 823-R-95-007). Fish tissue samples were not affected by deviating from the SOP procedures. The quality of tissue data generated at WES was assured by incorporating a variety of quality control samples, including:

1) Laboratory Reagent Blank/Method Blank (LRB) – Clean clam tissue matrix extracted with every sample set to ensure that the system is free of target analytes (< MDL) and to assess the potential for blank contamination.

2) Laboratory Fortified Blank (LFB) – Clean clam tissue matrix spiked with a low concentration of target compounds. LFB results are used to establish *accuracy* of system's performance. The acceptable laboratory % recovery range is typically 80 – 120%.

3) Laboratory Fortified Matrix (LFM) – Tissue matrix spiked with a low concentration of a target compound. LFM results are used to establish *accuracy* of the extraction and analytical process. The acceptable laboratory % recovery range is typically between 70 – 130% for metal analysis and 60 –140% for PCB/Organochlorine Pesticide analysis.

4) Quality Control Standard (QCS) – A pre-spiked secondary tissue sample. QCS results are used to establish *accuracy* in the extraction and test methods. The acceptable laboratory % recovery range is typically between 80–120%.

The WES Laboratory is solely responsible for the administration of its Quality Assurance Program and Standard Operating Procedures. Refer to WES's Quality Assurance Plan (MA DEP 1995) for specific laboratory analytical QA/QC criteria. WES laboratory releases tissue data when their established QA/QC criteria are met.

### A.1.3 *In-situ* Water Quality Data

A detailed QA/QC assessment of Hydrolab® pre-survey calibration and check, post survey check and data reduction activities for the 1998 Blackstone River watershed data can be found in the 1998 Hydrolab® QAQC Assessment Report (MA DEP 1998)

Trained DWM staff members conducted *in-situ* measurements using a Hydrolab®. The instrument measures dissolved oxygen, temperature, pH, conductivity, depth and turbidity and calculates total dissolved solids and % saturation of oxygen. To ensure the quality of the *in-situ* data, the following QA/QC steps were taken:

1.0 Pre- Survey Calibration and Check: Standard pre-survey calibration of the Hydrolab® unit was conducted in accordance with the DWM SOP for Hydrolab® use (MA DEP 1999d). After the instrument was calibrated and before the instrument was released to field staff, an instrument check using both a low ionic standard and filtered de-ionized water was performed. The purpose of this check is to make sure that the instrument is providing stable readings as the waters in Massachusetts are typically of low ionic strength. If the instrument failed acceptance criteria, it was not released to field staff until the source of error was identified and corrected.

2.0 Post Survey Check: A standard post survey check of the Hydrolab® unit was performed in accordance with the DWM SOP for Hydrolab® use (MA DEP 1999d). Upon return of the Hydrolab® unit to DWM's lab after a survey run, a visual inspection was performed to identify any physical damage that may have occurred in the field. The calibration of the unit was then checked against both a low ionic standard and filtered de-ionized water. The results of the post survey calibration check were compared to the pre-calibration results. If visual damage was observed and/or post calibration acceptance criteria were not achieved, the source of error was investigated and data collected in the field may have been subject to qualification or censoring.

3.0 Data Reduction: The Hydrolab® Coordinator and Database Manager reviewed the Hydrolab® data for instability, instrument malfunction, operator technique and aberrant trends. If any of these conditions were detected, the data was investigated and may have been recommended for censoring. The Database Manager electronically tagged all data recommended for censoring in the database.

## A.2 QA/QC Data Validation

Field blank and field replicate sampling results for the discrete water quality sampling (physical/chemical and bacteriological) are provided in Tables A.2-1 through A.2-4. DEP DWM QA/QC water quality data is managed and maintained in the *Water Quality Data Access Database*. Tables A.2-5 through A.2-9 contain laboratory QA/QC data for organics and metals in fish tissue.

### A.2.1 Discrete Water Sample Data

1998 Blackstone River water quality QC data were reviewed using the four main criteria and other information (field notes, personal communication, etc.) as follows.

Sample/Analysis Holding Time: With the following exception, all samples were analyzed within established analyte method holding times:

1) OWMID# 51-0024-30 for ***TKN*** (32 days, approx. 4 days over HT); sample results were accepted (minor exceedance of HT).

2) OWMID#51-0024-30 for ***ortho-P*** (8 days, 6 days over HT); sample results were censored.

QC Sample Frequency: All trips included 10% blanks and duplicates.

Field Blanks: See tables. All blank samples showed no analyte concentrations above the method detection limit.

Field Duplicates: Note: Small differences between replicate values at or near a low MDL will result in an increase in relative percent difference (%RPD) value. This increase can create a false impression that replicate data are not meeting their set quality control limits. For replicate values at or near method detection limits (≤1 mg/L), a 30% RPD data quality objective was applied to help counter this statistical effect. Replicate values > 1mg/L were reviewed independently against other quality control factors (i.e. field blank data, documentation) and a decision made on their validity.

1) OWMID #51-0014 and 0015: The duplicate results for ***Turbidity*** were suspected of being outliers (not indicative of actual conditions). It is important to note that the Blackstone (51) replicate had been collected using the "bucket" technique. No problems were noted on the chain of custody or the OWM field sheet. Because there was not enough evidence to censor these replicate results, the data were accepted.

2) OWMID#51-0014 and 0015; 51-0052 and 0054: The ***Ammonia*** duplicate results fell outside of the stated data quality objective of 30% RPD. This may be an artifact of using the "bucket" sampling technique. These replicate results are very close to the low-level method detection limit of 0.02mg/L (see note above). No problems were noted on the chain of custody or the OWM field sheet. Because there was not enough evidence to censor these replicate results, the data were accepted.

3) OWMID#51-0032 and 0033: The ***Nitrate*** duplicate results fell outside of the stated data quality objective of 30% RPD. This may be an artifact of using the "bucket" sampling technique. These replicate results are very close to the low-level method detection limit of 0.02mg/L (see note above). No problems were noted on the chain of custody or the OWM field sheet. Because there was not enough evidence to censor these replicate results, the data were accepted.

Other Information: Miscellaneous information resulting in acceptance or censoring of data is as follows.

1) OWMID# 51-0020 and -0021: The coordinator for the Blackstone (51) 5/12/98 survey noted improper bacteria sample collection techniques by newly trained staff on the OWM field sheet. Data results were consistently much higher than associated station data for the 1998 sampling surveys. Therefore, sample results for ***Fecal Coliform, Enterococcus, E-coli*** and all associated bacteria data from 5/12/98 were censored.

**Table A.2-1.** 1998 DEP DWM Blackstone River Basin instream bacteriological QA/QC field blank data. (cfu/100mLs.)

| | | | Time (24hr) | FECAL | E-COLI | ENTEROCOCCUS |
|---|---|---|---|---|---|---|
| **Field Blank Sample** | | | | | | |
| 51-0022 | BLANK | 05/12/98 | 12:21 | ** | ** | ** |
| 51-0030 | BLANK | 06/09/98 | 11:30 | <20 | -- | -- |
| 51-0034 | BLANK | 07/08/98 | ** | <20 | -- | -- |
| 51-0043 | BLANK | 07/08/98 | 10:56 | <20 | -- | -- |
| 51-0053 | BLANK | 08/04/98 | 11:00 | <16 | -- | -- |
| 51-0078 | BLANK | 09/02/98 | 10:00 | <16 | -- | -- |
| 51-0084 | BLANK | 09/30/98 | 11:50 | <16 | -- | -- |
| 51-0091 | BLANK | 10/27/98 | 11:19 | <6 | -- | -- |

** = missing/censored data -- = no data <#= less than MDL

**Table A.2-2**. 1998 DEP DWM Blackstone River Basin instream bacteriological QA/QC field replicate data. (cfu/100mLs, log10 transformed.)

| | | | Time (24hr) | FECAL | E-COLI | ENTEROCOCCUS |
|---|---|---|---|---|---|---|
| **Unnamed and/or Undefined SARIS, Station: SP01W** | | | | | | |
| 51-0014 | 51-0015 | 05/19/98 | 11:20 | -- | -- | -- |
| 51-0015 | 51-0014 | 05/19/98 | 11:20 | -- | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | | | |
| **Unnamed and/or Undefined SARIS, Station: KB02** | | | | | | |
| 51-0041 | 51-0042 | 07/08/98 | 10:41 | 1.602 | -- | -- |
| 51-0042 | 51-0041 | 07/08/98 | 10:41 | 1.301 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *20.7%* | | |
| **BLACKSTONE RIVER, Station: BLK01** | | | | | | |
| 51-0028 | 51-0029 | 06/09/98 | 9:48 | 2.763 | -- | -- |
| 51-0029 | 51-0028 | 06/09/98 | 9:48 | 3.041 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *9.6%* | | |
| **MILL RIVER, Station: BLK15-1** | | | | | | |
| 51-0032 | 51-0033 | 07/08/98 | 10:57 | 2.000 | -- | -- |
| 51-0033 | 51-0032 | 07/08/98 | 10:57 | 1.903 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *5.0%* | | |
| **WEST RIVER, Station: WR12** | | | | | | |
| 51-0074 | 51-0077 | 09/02/98 | 9:16 | 3.301 | -- | -- |
| 51-0077 | 51-0074 | 09/02/98 | 9:16 | 3.380 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *2.4%* | | |
| **DARK BROOK, Station: RB01** | | | | | | |
| 51-0052 | 51-0054 | 08/04/98 | 10:25 | 1.914 | -- | -- |
| 51-0054 | 51-0052 | 08/04/98 | 10:25 | 1.914 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *0.0%* | | |
| **Unnamed and/or Undefined SARIS, Station: BB04** | | | | | | |
| 51-0020 | 51-0021 | 05/12/98 | 12:21 | ** | ** | ** |
| 51-0021 | 51-0020 | 05/12/98 | 12:21 | ** | ** | ** |
| ***Relative Percent Difference (RPD):*** | | | | | | |
| 51-0082 | 51-0083 | 09/30/98 | 11:50 | 2.892 | -- | -- |
| 51-0083 | 51-0082 | 09/30/98 | 11:50 | 2.903 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *0.4%* | | |
| 51-0089 | 51-0090 | 10/27/98 | 11:20 | 1.875 | -- | -- |
| 51-0090 | 51-0089 | 10/27/98 | 11:20 | 1.748 | -- | -- |
| ***Relative Percent Difference (RPD):*** | | | | *7.0%* | | |

** = missing/censored data  -- = no data

**Table A.2-3.** 1998 DEP DWM Blackstone River Basin instream physico-chemical QA/QC field blank data. (All units expressed in mg/L unless otherwise specified.)

| | | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos/cm) | Chloride | Suspended Solids | Total Solids | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field Blank Sample** | | | | | | | | | | | | | | |
| 51-0022 | BLANK | 05/12/98 | 12:21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0016 | BLANK | 05/19/98 | 11:30 | -- | <0.66 | -1 | -- | <1.0 | -- | <0.1 | -- | <0.02 | <0.02 | <0.01 |
| 51-0030 | BLANK | 06/09/98 | 11:30 | 3.0 | <0.70 | -- | <1.0 | <1.0 | -- | <0.1 | ** | <0.02 | <0.02 | <0.01 |
| 51-0034 | BLANK | 07/08/98 | ** | 2.0 | <0.66 | 1.5 | <1.0 | <1.0 | -- | <0.1 | <0.1 | <0.02 | 0.02 | <0.01 |
| 51-0043 | BLANK | 07/08/98 | 10:56 | 2.0 | <0.66 | 1.5 | <1.0 | <1.0 | -- | <0.1 | <0.1 | <0.02 | <0.02 | <0.01 |
| 51-0053 | BLANK | 08/04/98 | 11:00 | 1.0 | <0.66 | -- | <1.0 | <1.0 | -- | 0.10 | -- | <0.02 | <0.02 | <0.01 |
| 51-0078 | BLANK | 09/02/98 | 10:00 | 2.0 | <0.66 | -- | <1.0 | <1.0 | -- | 0.10 | <0.1 | <0.02 | <0.02 | <0.01 |
| 51-0084 | BLANK | 09/30/98 | 11:50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0091 | BLANK | 10/27/98 | 11:19 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

** = missing/censored data -- = no data

**Table A.2-4.** 1998 DEP DWM Blackstone River Basin instream physico-chemical QA/QC field duplicate data. (All units expressed in mg/L unless otherwise specified.)

| | | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos) | Chloride | Suspended Solids | Total Solids | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unnamed and/or Undefined SARIS, Station: SP01W** | | | | | | | | | | | | | | |
| 51-0014 | 51-0015 | 05/19/98 | 11:20 | -- | 71 | 500 | -- | 6.0 | -- | 6.0 | -- | 0.04 | 0.46 | 0.07 |
| 51-0015 | 51-0014 | 05/19/98 | 11:20 | -- | 71 | 500 | -- | 6.2 | -- | 5.6 | -- | 0.10 | 0.46 | 0.07 |
| *Relative Percent Difference (RPD):* | | | | | *0.0%* | *0.0%* | | *3.3%* | | *6.9%* | | *85.7%* | *0.0%* | *0.0%* |
| **Unnamed and/or Undefined SARIS, Station: KB02** | | | | | | | | | | | | | | |
| 51-0041 | 51-0042 | 07/08/98 | 10:41 | 23 | 35 | 210 | 42 | <1.0 | -- | 2.9 | 0.41 | <0.02 | 0.07 | 0.06 |
| 51-0042 | 51-0041 | 07/08/98 | 10:41 | 23 | 35 | 210 | 41 | <1.0 | -- | 2.9 | 0.39 | <0.02 | 0.06 | 0.06 |
| *Relative Percent Difference (RPD):* | | | | *0.0%* | *0.0%* | *0.0%* | *2.4%* | *0.0%* | | *0.0%* | *5.0%* | *0.0%* | *15.4%* | *0.0%* |
| **BLACKSTONE RIVER, Station: BLK01** | | | | | | | | | | | | | | |
| 51-0028 | 51-0029 | 06/09/98 | 9:48 | 36 | 70 | -- | 83 | 2.2 | -- | 2.4 | ** | 0.04 | 0.37 | 0.06 |
| 51-0029 | 51-0028 | 06/09/98 | 9:48 | 36 | 71 | -- | 79 | 2.4 | -- | 2.9 | ** | 0.05 | 0.37 | 0.06 |
| *Relative Percent Difference (RPD):* | | | | *0.0%* | *1.4%* | | *4.9%* | *8.7%* | | *18.9%* | | *22.2%* | *0.0%* | *0.0%* |
| **MILL RIVER, Station: BLK15-1** | | | | | | | | | | | | | | |
| 51-0032 | 51-0033 | 07/08/98 | 10:57 | 14 | 21 | 160 | 31 | 2.7 | -- | 2.3 | 0.43 | <0.02 | 0.29 | 0.07 |
| 51-0033 | 51-0032 | 07/08/98 | 10:57 | 14 | 21 | 160 | 33 | 2.5 | -- | 2.2 | 0.40 | <0.02 | 0.40 | 0.07 |
| *Relative Percent Difference (RPD):* | | | | *0.0%* | *0.0%* | *0.0%* | *6.3%* | *7.7%* | | *4.4%* | *7.2%* | *0.0%* | *31.9%* | *0.0%* |
| **WEST RIVER, Station: WR12** | | | | | | | | | | | | | | |
| 51-0074 | 51-0077 | 09/02/98 | 9:16 | 18 | 24 | -- | 42 | 2.0 | -- | 2.8 | 0.46 | <0.02 | 0.09 | 0.04 |
| 51-0077 | 51-0074 | 09/02/98 | 9:16 | 17 | 24 | -- | 42 | 2.2 | -- | 2.7 | 0.44 | 0.02 | 0.10 | 0.04 |
| *Relative Percent Difference (RPD):* | | | | *5.7%* | *0.0%* | | *0.0%* | *9.5%* | | *3.6%* | *4.4%* | *0.0%* | *10.5%* | *0.0%* |
| **DARK BROOK, Station: RB01** | | | | | | | | | | | | | | |
| 51-0052 | 51-0054 | 08/04/98 | 10:25 | 36 | 61 | -- | 82 | 1.0 | -- | 1.5 | -- | 0.03 | 0.28 | 0.03 |
| 51-0054 | 51-0052 | 08/04/98 | 10:25 | 36 | 61 | -- | 82 | 1.1 | -- | 1.4 | -- | 0.05 | 0.29 | 0.03 |
| *Relative Percent Difference (RPD):* | | | | *0.0%* | *0.0%* | *0.0%* | *9.5%* | | | *6.9%* | | *50.0%* | *3.5%* | *0.0%* |
| **Unnamed and/or Undefined SARIS, Station: BB04** | | | | | | | | | | | | | | |
| 51-0020 | 51-0021 | 05/12/98 | 12:21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0021 | 51-0020 | 05/12/98 | 12:21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *Relative Percent Difference (RPD):* | | | | | | | | | | | | | | |
| 51-0082 | 51-0083 | 09/30/98 | 11:50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0083 | 51-0082 | 09/30/98 | 11:50 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *Relative Percent Difference (RPD):* | | | | | | | | | | | | | | |
| 51-0089 | 51-0090 | 10/27/98 | 11:20 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0090 | 51-0089 | 10/27/98 | 11:20 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *Relative Percent Difference (RPD):* | | | | | | | | | | | | | | |

** = missing/censored data -- = no data

### A.2.2 Fish Tissue Data

Estimates for laboratory precision and accuracy for fish tissue analysis were all within acceptable limits. Tables A.2-5 through A.2-9 provide specific QA/QC data.

**Table A.2-5.** 1998 DEP DWM Blackstone River Basin laboratory QA/QC data for metals in fish tissue. (Data expressed in ug/g wet weight unless otherwise noted.)

| | | Precision | | | Accuracy | | | Accuracy* (%Recovery) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Analyte | Sample | Duplicate | RPD | Spike Amount | LFM | Recovery (%) | LFB | QCS | MDL | Analytical Method |
| L980444-2 | As | 0.077 | 0.075 | 2.6% | 2.01 | 1.56 | 74 | 97 | 83 | 0.040 | EPA 200.9 |
| L980444-2 | Pb | <MDL | <MDL | NA | 2.01 | 2.13 | 96 | 98 | 95 | 0.2 | EPA 200.7 |
| L980444-2 | Cd | <MDL | <MDL | NA | 2.01 | 1.89 | 93 | 91 | 100 | 0.02 | EPA 200.7 |
| L980444-2 | Se | 0.265 | 0.283 | 6.6% | 2.01 | 2.46 | 109 | 109 | 84 | 0.040 | EPA 200.9 |
| L980444-6 | Hg | 0.064 | 0.074 | 14.5% | 0.083 | 0.17 | 116 | 91 | 96 | 0.01 | EPA 245.6 |

LFB – Laboratory Fortified Blank
LFB – Laboratory Fortified Matrix
MDL – Miethod Detection Limit

NA – Not Applicable
QCS – Quality Control Sample
RPD – Relative Percent Difference

*see Appendix A section A.1.2. for further details

**Table A.2-6.** 1998 DEP DWM Blackstone River Basin laboratory QA/QC blank data for organics in fish tissue.

| DATE ANALYZED | LABORATORY SAMPLE NUMBER | ANALYTE | | |
|---|---|---|---|---|
| | | % Lipid | Pesticides | PCB's |
| 22 December 1998 | BLANK - 1 | 0.15 | ND | ND |
| 30 December 1998 | BLANK - 2 | 0.16 | ND | ND |
| 7 January 1999 | BLANK - 3 | 0.08 | ND | ND |
| 3 February 1999 | BLANK - 4 | 0.11 | ND | ND |
| 4 February 1999 | BLANK - 5 | 0.08 | ND | ND |
| 5 February 1999 | BLANK - 6 | 0.16 | ND | ND |
| 9 February 1999 | BLANK - 7 | 0.18 | ND | ND |
| 10 February 1999 | BLANK - 8 | 0.14 | ND | ND |
| 11 February 1999 | BLANK - 9 | 0.20 | ND | ND |
| 12 February 1999 | BLANK - 10 | 0.12 | ND | ND |

**ND** - Not detected

**Table A.2-7.** 1998 DEP DWM Blackstone River Basin laboratory QA/QC duplicate data for organics in fish tissue. The analytes were extracted and analyzed according to modified AOAC 983.21 procedure for the analysis of PCBs and Organochlorine Pesticides. (Data expressed in $\mu$g/g wet weight unless otherwise noted.)

| DATE ANALYZED | LABORATORY SAMPLE NUMBER | ANALYTE | | |
|---|---|---|---|---|
| | | Pesticides* | PCBs | % Lipid |
| 29 December 1998 | L980381-3 | ND | ND | 0.23 |
| | L980381-3 duplicate | ND | ND | 0.67 |
| | relative percent difference | NA | NA | NA |
| 3 February1999 | L980445-1 | DDE* 0.021 | ND | 0.17 |
| | L980445-1 duplicate | DDE* 0.018 | ND | 0.11 |
| | relative percent difference | DDE* 15.4% | NA | NA |
| 5 February 1999 | L980538-2 | ND | ND | 0.38 |
| | L980538-2 duplicate | ND | ND | 0.32 |
| | relative percent difference | NA | NA | NA |
| 12 February 1999 | L980610-3 | ND | ND | 0.17 |
| | L980610-3 duplicate | ND | ND | 0.20 |
| | relative percent difference | NA | NA | NA |

***NOTE:** Fish tissue organic analytes (listed in Section A.3) not appearing in the above table were included in the analysis and were not detected. **ND** - not detected **NA** - not applicable

**Table A.2-8.** 1998 DEP DWM Blackstone River Basin laboratory QA/QC lab fortified matrix and matrix spike duplicate data for organics in fish tissue. The analytes were extracted and analyzed according to modified AOAC 983.21 procedure for the analysis of PCBs and Organochlorine Pesticides. (Data expressed in µg/g wet weight unless otherwise noted.)

| DATE ANALYZED | 29 December 1998 | 4 February 1999 | 11 February 1999 | 11 February 1999 |
|---|---|---|---|---|
| LABORATORY SAMPLE NUMBER | Matrix Spike L980381-1 | Matrix Spike L980522-3 | Matrix Spike L980609-1 | Matrix Spike Duplicate L980609-1 |
| %LIPIDS | 0.07 | 0.06 | 0.07 | 0.07 |
| ANALYTE | PCB A1260 MDL 0.11 | TOXAPHENE MDL 0.11 | PCB A1260 MDL 0.11 | PCB A1260 MDL 0.11 |
| Expected | 0.92 | 0.96 | 0.99 | 0.95 |
| Lab Fortified Matrix | 0.78 | 0.84 | 1.13 | 0.97 |
| Recovery (%) | 85 | 88 | 114 | 102 |

**NOTE:** Blackstone River samples were batched with others. These laboratory fortified matrix results are pertinent to Blackstone samples. **MDL** – method detection limit

**Table A.2-9.** 1998 DEP DWM Blackstone River Basin laboratory QA/QC lab fortified blank data for organics in fish tissue. The analytes were extracted and analyzed according to modified AOAC 983.21 procedure for the analysis of PCBs and Organochlorine Pesticides. (Data expressed in µg/g wet weight unless otherwise noted.)

| DATE ANALYZED | 30 December 1998 | 7 January 1999 |
|---|---|---|
| LABORATORY SAMPLE NUMBER | Laboratory fortified blank #1 | Laboratory fortified blank #2 |
| %LIPIDS | 0.09 | 0.25 |
| ANALYTE | CHLORDANE MDL 0.044 | PCB A1242 MDL 0.26 |
| Expected | 1.85 | 2.0 |
| Lab Fortified Matrix | 1.69 | 2.2 |
| Recovery (%) | 91 | 110 |

**NOTE: :** Blackstone River samples were batched with others. These laboratory fortified blank results are pertinent to Blackstone samples. **MDL** – method detection limit

### A.2.3 In-Situ Water Quality Data

Parameters measured or calculated by field Hydrolab® units (D.O., pH, conductivity, temperature, turbidity, total dissolved solids and % oxygen saturation) were examined for validity. Data that were tagged by the Hydrolab® with special symbols or that showed instability were censored.

For 1998 Blackstone basin sampling, the following OWMID #s and parameters were censored:

1) OWMID #51-0057, -0058, -0059, -0060, -0061, -0062 and -0063: All parameter values were censored because the Hydrolab® SOP was not followed. Specifically, the required number of recorded sets of readings was not stored into the Surveyor loggers. The SOP calls for a specific number of recordings at one-minute intervals prior to the last, final recording to account for variable temperature equilibrium by the individual probes. Not adhering to this aspect of the method SOP introduces uncertainty with regard to the accuracy of individual probe measurements. As a result, the data for **D.O., pH, conductivity, temperature, turbidity, total dissolved solids and % oxygen saturation** for these OWMIDs were censored.

2) OWMID #51-0040, -0041, -0044, and –0045: Values for **Turbidity** were censored, due to light interference noted by the Hydrolab® (denoted by Hydrolab® special symbol). Light interference affects the accuracy of the turbidity readings

3) OWMID #51-0039: Values for **Turbidity** were censored, due to wide fluctuation in the recorded instrument readings for turbidity taken at one-minute intervals. This indicates that the turbidity readings were not stable when the readings were stored, introducing unacceptable uncertainty regarding the accuracy of the final reading.

## A.3 Analytical Methods and MDLs

| Discrete Water Sample Analytes | EPA Method* | SM Methods** | Other Methods | MDLs |
|---|---|---|---|---|
| Fecal Coliform | | SM 9222D | | 16 CFU |
| Specific Conductivity | | SM 2510B | | 1.0mg/l |
| Alkalinity | | SM 2320B | | 1 mg/l |
| Chloride (4500) | | SM 4500CL-B | | 1 mg/l |
| Hardness | EPA 200.7 | | | 0.66mg/l |
| Turbidity | EPA 180.1 | | | 0.1 NTU |
| Ammonia-N | EPA 350.1 | | | 0.02mg/l |
| Nitrate/Nitrite-N | EPA 353.1 | | | 0.02mg/l |
| Kjeldahl-N | EPA 351.2 | | | 0.10mg/l |
| Phosphorus-P | | SM 4500P-E | | 0.010 " |
| Phosphorus-P (Manual) | | SM 4500P-E | | 0.005 " |
| Suspended Solids | | SM 2540D | | 1.0 mg/l |
| Total Petroleum Hydrocarbons (silica-gel treated/hexane extractable material) | EPA 1664 | | | 0.28mg/l |

Fish Tissue Analytes

| | | | ug/g wet wt. |
|---|---|---|---|
| PCB Arochlor 1242 | | AOAC 983.21*** | 0.26 |
| PCB Arochlor 1254 | | " | 0.37 |
| PCB Arochlor 1260 | | " | 0.11 |
| Chlordane | | " | 0.044 |
| Toxaphene | | " | 0.11 |
| a-BHC | | " | 0.017 |
| b-BHC | | " | 0.014 |
| Lindane | | " | 0.012 |
| d-BHC | | " | 0.029 |
| Hexachlorocyclopentadiene | | " | 0.0077 |
| Trifluralin | | " | 0.0062 |
| Hexachlorobenzene | | " | 0.0091 |
| Heptachlor | | " | 0.013 |
| Heptachlor Epoxide | | " | 0.013 |
| Methoxychlor | | " | 1.07 |
| DDD | | " | 0.010 |
| DDE | | " | 0.014 |
| DDT | | " | 0.013 |
| Aldrin | | " | 0.0092 |
| Arsenic | EPA 200.9 | | 0.040 |
| Lead | EPA 200.7 | | 0.20 |
| Selenium | EPA 200.9 | | 0.040 |
| Cadmium | EPA 200.7 | | 0.02 |
| Mercury | EPA 245.6 | | 0.01 |

In-Situ Water Quality Analytes

| | |
|---|---|
| Hydrolab® Multiprobe Series 3 analyzer (MA DEP 1999d) | NA |

* = "Methods for Chemical Analysis of Water and Wastes", Environmental Protection Agency, Environmental Monitoring Systems Laboratory – Cincinnati (EMSL-CI), EPA-600/4-79-020, Revised March 1983 and 1979 where applicable.
** = Standard Methods, Examination of Water and Wastewater, 20th edition
*** = PCBs and Organochlorine Pesticides in Biological Tissue, AOAC Official Methods of Analysis, 1990
NA = Not Applicable

## CONCLUSION

The Blackstone River Basin water quality data collected in 1998 was reviewed with regard to project data quality objectives (DQOs) and adherence to DEP/DWM and WES Laboratory SOPs for collection and analysis. The primary DQO elements of precision, accuracy, representativeness, completeness and comparability (PARCC) were evaluated.

With few exceptions, the precision and accuracy of sampling and analysis met performance criteria. Where exceptions occurred, there was typically not enough justification to censor the data. In the case of Hydrolab® data OWMID numbers 51-0057 through -0063 taken on August 6 and 7, all data were censored due to poor field implementation of the Hydrolab® SOP. In the case of OWMID numbers 51-0039, -0040, -0041, -0044 and -0045 taken on July 8, turbidity data were censored due to light interference or unstable readings.

With the exception of 5/12/98 bacteria data (censored due to improper field collection technique), the sample data collected was representative of the conditions in the basin at the time of sampling.

Accounting for all censored data, percent completeness was greater than 90%, meeting the project DQO.

The comparability of the 1998 Blackstone River Basin data set to past and future data collected by DWM and others is considered good, based on the use of standardized methods for typical parameters. Although the use of buckets for sample collection from drop locations may change in the future, use of the bucket method has been noted and, while its use may affect data quality for solids-related analytes (e.g., TSS, turbidity, nutrients, etc.), the data is considered comparable to other data collected via other grab sampling methods.

## REFERENCES


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# APPENDIX B - 1998 DEP DWM BLACKSTONE RIVER BASIN SURVEY REPORT

## MATERIALS AND METHODS

The DWM began sampling in May 1998 and continued through October 1998. The DWM sampling plan matrix is summarized in Table B1. Sampling components at river stations included *in-situ* Hydrolab® Multiprobe Series 3 analyzer (hereafter referred to as Hydrolab®) measurements, physico-chemical and nutrient sampling, fecal coliform bacteria sampling, benthic macroinvertebrate sampling, periphyton and chlorophyll a sampling, fish population, toxics in fish flesh and sediment. Synoptic surveys of lakes were conducted during August and September 1998 to coincide with the maximum extent of macrophyte growth. Each sampling component is described in the sections that follow.

**Table B1.** 1998 Blackstone Basin Survey DEP DWM sampling matrix.

| WATERBODY | STATION[1] | 1998 May | 1998 June | 1998 July | 1998 August | 1998 September | 1998 October |
|---|---|---|---|---|---|---|---|
| Kettle Brook, upstream from Segment MA51-01 | KB10 | | | C, N, B, H, Q,M, P | | | |
| Kettle Brook, Segment MA51-01 | KB09 | | | C, N, B, H, Q, M | F | | |
| | KB02 | | C, N, B, H, Q | C, N, B, H, Q, M, P | C, N, B, H, Q | | |
| Dark Brook (MA51-16) | RB01 | | | C, N, B, H, Q, M, P | C, N, B, H, Q, F | | |
| Coes Reservoir (upstream of Segment MA51-02) | F0060 | | | T | | | |
| Coes Pond (just upstream of Segment MA51-02) | TB01 | | C, N, B, H, Q | C, N, B, H, Q | C, N, B, H, Q | | |
| Middle River (MA51-02) | Middle Riv | | | H (fish kill response) | | | |
| | BLK00 | | C, N, B, H | C, N, B, H | C, N, B, H | | |
| | B0097(BLK00A) | | | M, P | | | |
| Beaver Brook (MA51-07) | BB02 | B | | | | B | B |
| | BB01 | B, H | C, N, B, H, Q | C, N, B, H, Q | C, N, B, H | B | B |
| unnamed | BB04 | B, H | | | | B | B |
| unnamed | BB05 | B | | | | B | B |
| unnamed | BB03 | B, H | | | | B | B |
| Tatnuck Brook (MA51-15) | B0101 (TB02) | | | M, P | F | | |
| "Mill Brook" (MA51-08) | SP01W | C, N | | | | | |
| | SP01E | C, N | | | | | |
| | SP04E | C, N | | | | | |
| | SP04W | C, N | | | | | |
| | SP03E | C, N | | | | | |
| | SP03W | C, N | | | | | |

[1]Samping did not necessarily occur at the same exact location although that which occurred in the general vicinity of the sampling station is listed together.

**A**=Chlorophyll a; **B**=Bacteria (fecal coliform, E. coli, Enterococcus); **C**=Chemistry (alkalinity, hardness, specific conductivity, chlorides, total solids, suspended solids, turbidity); **F**=Fish population; **H**= Hydrolab® multiprobe meter (pH, dissolved oxygen, conductivity, temperature, total dissolved solids, percent saturation, depth, turbidity); **M**=Macroinvertebrate kick sampling and habitat assessment; **N**=Nutrients (total phosphorus, ammonia, nitrate/nitrite-nitrogen); **P**=Periphyton, **Q**= Flow; **T**=Toxics in fish tissue (Cd, Pb, Hg, As, Se, % lipids, PCBs, organochlorine pesticides)

Chlorophyll a (**A**), periphyton (**P**) and Macroinvertebrate kick sampling and habitat assessment (**M**) results are provided in the 1998 DEP DWM Biomonitoring Technical Memorandum (Appendix C)

**Table B1.** Continued. 1998 Blackstone Basin Survey DEP DWM sampling matrix.

| WATERBODY | STATION[1] | 1998 May | 1998 June | 1998 July | 1998 August | 1998 September | 1998 October |
|---|---|---|---|---|---|---|---|
| | SP02E | C, N | | | | | |
| | SP02W | C, N | | | | | |
| "University Park Pond" | F0059 | | | T | | | |
| Blackstone River (MA51-03) | BLK01 | | C, N, B, H, Q | C, N, B, H, Q, M, P | C, N, B, H, Q | | |
| | BLK02 | | | C, N, B, H, M, P | | | |
| Singing Dam impoundment | 669 | | | | H, A | | |
| Fisherville Pond impoundment | 668 | | | | H, A | | |
| Blackstone River (MA51-04) | BLK07-A | | | C, N, B, H | | | |
| | B0093 (BLK07) | | | M, P | | | |
| Rice City Pond impoundment | 670 | | | | H | | |
| Blackstone River (MA51-05) | BLK12A | | | C, N, B, H, M | | | |
| Mumford River (MA51-13) | BLK09-8 | | | C, N, B, H | | | |
| | B0091 (BLK09-8A) | | | M, P | F | | |
| West River (MA51-11) | WR12 | | | | | C, N, B, H, Q | |
| West River (MA51-12) | WR10 | | | | | C, N, B, H | |
| | Q0054 | | | | | Q | |
| | B0092 (WR01) | | | M, P | F | | |
| | WR03 | | | | | C, N, B, H | |
| Center Brook | WR20 | | | | | C, N, B, H, Q | |
| Blackstone River (downstream from Segment MA51-06 in RI) | 667 | | | | H, A | | |
| Mill River (MA51-10) | BLK15-1 | | | C, N, B, H, M | F | | |

[1]Samping did not necessarily occur at the same exact location although that which occurred in the general vicinity of the sampling station is listed together.

**A**=Chlorophyll a; **B**=Bacteria (fecal coliform, E. coli, Enterococcus); **C**=Chemistry (alkalinity, hardness, specific conductivity, chlorides, total solids, suspended solids, turbidity); **F**=Fish population; **H**= Hydrolab® multiprobe meter (pH, dissolved oxygen, conductivity, temperature, total dissolved solids, percent saturation, depth, turbidity); **M**=Macroinvertebrate kick sampling and habitat assessment; **N**=Nutrients (total phosphorus, ammonia, nitrate/nitrite-nitrogen); **P**=Periphyton, **Q**= Flow; **T**=Toxics in fish tissue (Cd, Pb, Hg, As, Se, % lipids, PCBs, organochlorine pesticides)

Chlorophyll a (**A**), periphyton (**P**) and Macroinvertebrate kick sampling and habitat assessment (**M**) results are provided in the 1998 DEP DWM Biomonitoring Technical Memorandum (Appendix C)

## SURVEY CONDITIONS

Conditions prior to each survey were characterized by analyzing precipitation and streamflow data. Two weather station precipitation gages, Douglas # 511 and Worcester, were used to determine precipitation and weather conditions in the five days prior to and on the sampling dates. Data from these stations was provided by the DEM Office of Water Resources (MA DEM 1998). Discharge (hereinafter referred to as streamflow) and duration data were obtained from two USGS stream gage in the basin (see Figure B1), Quinsigamond River at North Grafton (01110000) and Blackstone River at Northbridge (0110500). Streamflow statistics for the period-of-record for the gage are available from USGS. This data can be found in their *Water Resources Data for Massachusetts and Rhode Island, Water Year 1998 and 1999* reports (Socolow *et al.*, 1999 and 2000). The period of record (POR) for the Quinsigamond River

(01110000) at North Grafton is from October 1939 to present and the period of record for the Blackstone River (01110500) at Northbridge is from October 1939 to present (intermittent).

In addition to gage data, streamflow was measured by DEP DWM personnel according to standard operating procedures (MA DEP 1990) at 11 stations using a Swoffer meter (model 2100). Data reduction and stream discharge calculations (Table B4) were performed at the DWM office in Worcester.

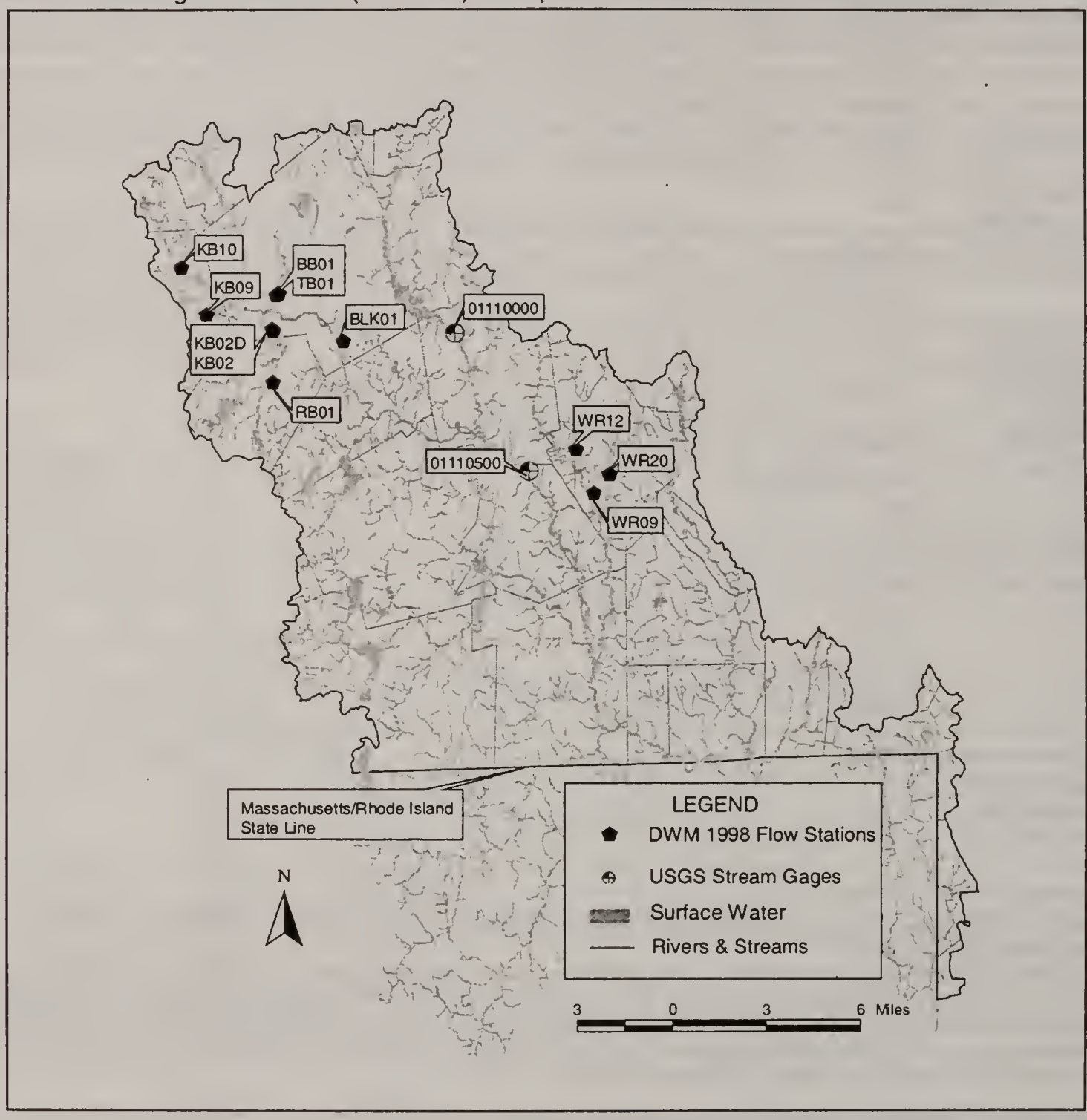


Figure B1. Location of USGS gaging stations and DEP DWM 1998 flow stations in the Blackstone River Basin.

## STREAM WATER QUALITY MONITORING

The water quality sampling effort was conducted at the stations identified in Figure B2. Sampling at these synoptic monitoring locations included some but not all of the following: *in situ* measurements using the Hydrolab® (measures dissolved oxygen, water temperature, pH, conductivity, depth and turbidity and calculates total dissolved solids and % oxygen saturation). Other parameters tested included: bacteria sampling (fecal coliform, E. coli, and Enterococcus). physico-chemical variables and nutrient concentrations (alkalinity, hardness, specific conductivity, chloride, suspended solids, total petroleum hydrocarbons, turbidity, total Kjeldahl nitrogen, ammonia, nitrate, and total phosphorus).

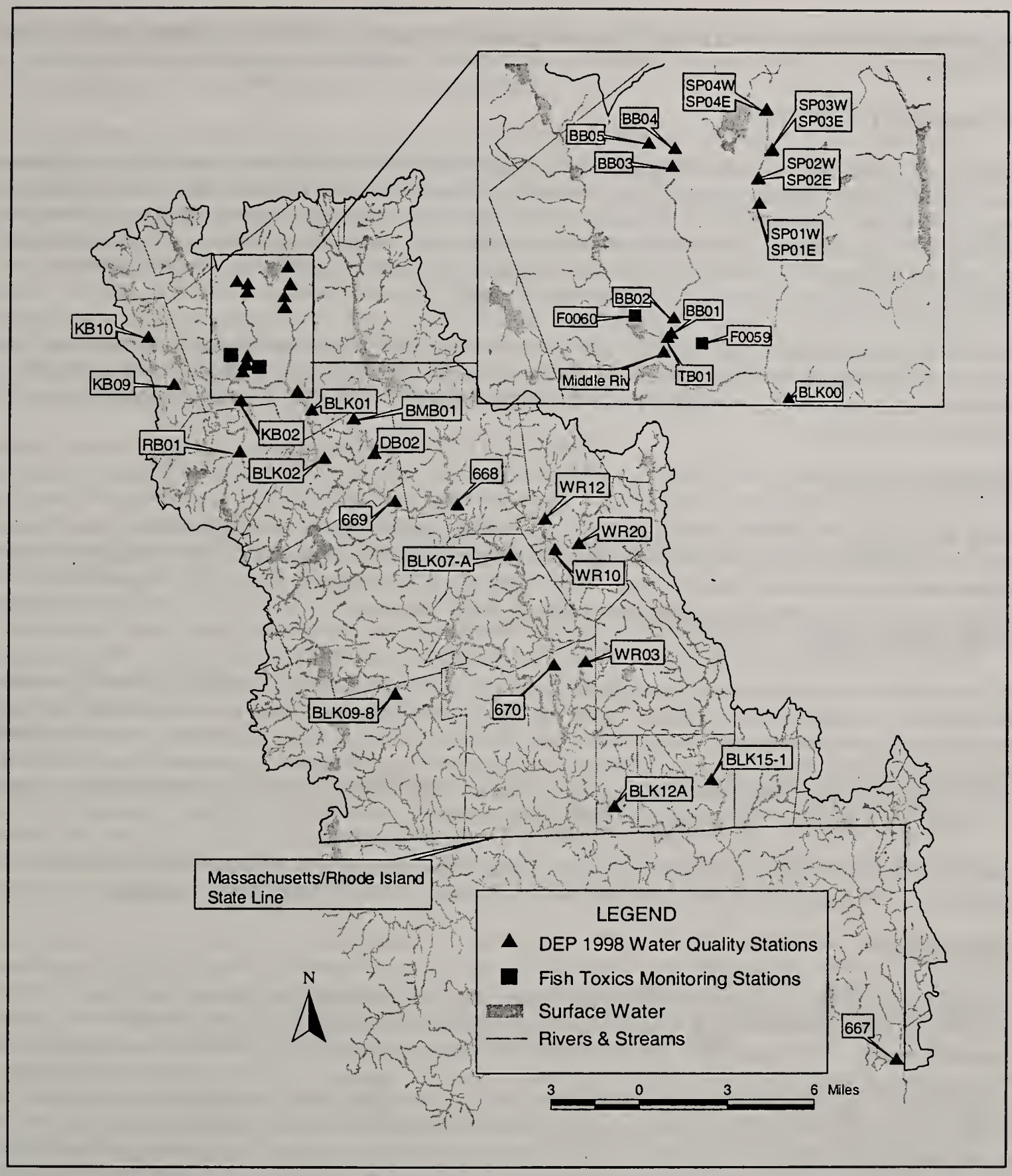


Figure B2. Location of 1998 water quality sampling stations in the Blackstone River Basin.

Procedures used for water sampling and sample handling are described in the *Grab Collection Techniques for DWM Water Quality Sampling Standard Operating Procedure* and the *Hydrolab® Series 3 Multiprobe Standard Operating Procedure* (MA DEP 1999a and 1999b). The Wall Experiment Station (WES), the Department's analytical laboratory, supplied all sample bottles and field preservatives, which were prepared according to the WES *Laboratory Quality Assurance Plan and Standard Operating Procedures* (MA DEP 1995). Samples were preserved in the field as necessary, transported on ice to WES, and analyzed according to the WES Standard Operating Procedure (SOP). The quality control protocol that was followed for field and equipment blank samples is described in Appendix A of this report. Both quality control samples (field blanks, trip blanks, and split samples) and raw water quality samples

were transported on ice to WES on each sampling date; they were analyzed subsequently according to the WES SOP.

## MACROINVERTEBRATES

Aquatic macroinvertebrates were collected from selected sites (Figure B3) within the Blackstone River Watershed by either kick-sampling or deployment of artificial substrates (Nuzzo 1999). Ten individual kicks taken within a 100-m reach of the selected stream were composited, representing a total sample area of 2 $m^2$. Collected material was transferred to a plastic jar, labeled, and preserved with denatured 95% ethanol (Appendix C). Habitat quality was scored at each sampling location following a habitat assessment procedure modified from Plafkin *et al.* (1989).

A technical memorandum (Appendix C) by John Fiorentino of DEP DWM entitled *Blackstone River Watershed 1998 Biological Assessment* presents the aquatic macroinvertebrate analysis (as well as details related to sample handling and processing) of samples collected from selected sites in the Blackstone River Basin.

## FISH POPULATION

During the summer of 1998 the DWM conducted a fish population survey in the Blackstone River Basin at Kettle Brook, Dark Brook, Tatnuck Brook, Mumford River, West River, and Mill River. The stations were located near six of the macroinvertebrate stations (B0099, B0096, B0101, B0091, B0092, B0089). Surveys were conducted using techniques similar to Rapid Bioassement Protocols V (fish) as described by Plafkin *et al.* (1989).

Fish populations were sampled by electrofishing using a Smith Root Model 12 battery powered backpack electrofisher. A reach of approximately 100m was sampled by passing a pole mounted anode ring side to side through the stream channel and in and around likely fish holding cover. All fish stunned were netted and held in buckets. Sampling proceeded from an obstruction or constriction, upstream to an endpoint at another obstruction or constriction such as a waterfall or shallow riffle. Following completion of a sampling run, all fish were identified to species, counted, and released.

A technical memorandum (Appendix C) by John Fiorentino of DEP DWM entitled *Blackstone River Watershed 1998 Biological Assessment* presents the results of the fish population sampling.

## FISH TOXICS

Fish toxics monitoring is aimed primarily at assessing human health risks associated with the consumption of freshwater fishes. The program is a cooperative effort between three DEP Offices/Divisions, (Watershed Management, Research and Standards, and Environmental Analysis), the Department of Fisheries and Wildlife Environmental Law Enforcement, and the Department of Public Health (DPH). Fish tissue monitoring is typically conducted to assess the concentrations of toxic contaminants in freshwater fish, identify waterbodies where those concentrations may pose a risk to human health, and identify waters where toxic chemicals may impact fish and other aquatic life. Fish tissue analysis has been restricted to edible fillets. The fish toxics monitoring was designed to screen the edible fillets of several species of fish representing different feeding guilds (i.e., bottom dwelling omnivores, top-level predators, etc.) for the presence of heavy metals (Pb, Cd, Se, Hg, As), PCBs and organochlorine pesticides and to assess human health risks associated with the consumption of freshwater fishes (MA DEP 1999c).

As recommended by the Blackstone River Watershed Team, sites in Worcester (Figure B2) that receive substantial fishing pressure were sampled to test the fish for human consumption considerations. The Team requested that DWM sample fish from University Park Pond, a small (1.8 acres) isolated pond that lies on the campus of Clark University. Coes Reservoir, a 90-acre impoundment that is the headwaters of the Middle River (a tributary to the Blackstone River) was also chosen as a fish toxics screening station.

Fish were collected via boat mounted electrofishing gear at University Park Pond by DWM staff on 2 July 1998. Coes Reservoir was sampled cooperatively by DWM and DWFELE, Central District on 7 and 8 July

1998 with boat mounted electrofishing gear as well as gill nets. Fish were held in an onboard livewell until an appropriate sample number was reached, at which time the samples were placed in an ice filled cooler and brought back to the DWM laboratory for processing.

Uniform protocols, designed to assure accuracy and prevent cross-contamination of samples, were followed for collecting, processing and shipping fish. Lengths and weights were measured and fish were visually inspected for tumors, lesions, or other anomalies. Scale or pectoral fin spine samples were obtained from each fish to determine age. Fish were filleted (skin off) on glass cutting boards and prepared for freezing. All equipment used in the filleting process was rinsed in tap water to remove slime, scales, and other fluids such as blood, then re-rinsed in deionized water before (and/or after) each sample. Individual and/or composite samples (single fillets from each of two or more like-sized individuals of the same species) targeted for % lipids, PCBs and organochlorine pesticide analysis were wrapped together in aluminum foil. The opposite fillet(s) targeted for metals analysis were placed in VWR 32-ounce high density polyethylene (HDPE) cups with covers. Samples were tagged and frozen for subsequent delivery to the Department's Wall Experiment Station (WES).

Methods used at WES for metals analysis include the following:
Mercury is analyzed by a cold vapor method using a Perkin Elmer, FIMS (Flow Injection Mercury System) which uses Flow Injection Atomic Absorption Spectroscopy. Cadmium and lead are analyzed using a Perkin Elmer, Optima 3000 XL ICP – Optical Emission Spectrophotometer. Arsenic and selenium are analyzed using a Perkin Elmer, Zeeman 5100 PC, Platform Graphite Furnace, Atomic Absorption Spectrophotometer.

PCB/organochlorine pesticide analysis was performed on a gas chromatograph equipped with an electron capture detector. Additional information on analytical techniques used at WES is available from the laboratory (MA DEP 1995).

**LAKES**

In the Blackstone River Basin there are 188 lakes, ponds or impoundments (the term "lakes" will hereafter be used to include all), covering 7,086.6 acres, that have been identified and assigned Pond and Lake Information System (PALIS) code numbers (Ackerman 1989 and MA DEP 2000). During August and September 1998 DWM synoptic surveys were conducted on 37 of these lakes (2,886 acres) covering 40.7% of the lake acreage (19.7% of the lakes) in the Blackstone River Basin.

Observations, from at least one access point on each lake (multiple access points on larger lakes), were recorded on standardized field sheets during the synoptic surveys. An attempt was made to observe the entire surface area of each lake to determine the extent of areal macrophyte cover. At each sampling location, general water quality conditions, identification and abundance of aquatic and wetland macrophyte plant species, and estimates of total percent areal coverage were recorded.

Macrophyte visual observations were augmented at each station by identifying plant specimens collected from the lake bottom. Specimens were retrieved utilizing a "rake" (a short handled, double-sided garden rake on a 50 foot line) thrown to its maximum extension in multiple directions at each station. Macrophytes collected on the "rake" were identified (in-situ or in the laboratory) and recorded on the field sheets (MA DEP 1998b).

Transparency was measured where possible using a standard 20-centimeter diameter Secchi disc attached to a rope with metric calibrations. When Secchi disk measurements were not feasible, transparency was estimated as being above or below 1.2 meters. This depth is based on the MA DPH bathing beach standard (4 foot Secchi disk depth) (MA DPH 1969).

Trophic status was estimated primarily using visual observations of macrophyte cover and phytoplankton populations. Trophic status (level of nutrient enrichment) determinations and designated use impairment assessments were made on site. Occasionally, older data from more detailed diagnostic studies were utilized. A more definitive assessment of trophic status would require more extensive collection of water quality and biological data.

# RESULTS

## SURVEY CONDITIONS

To fulfill the assessment guidance, information on precipitation (MA DEM 1998) and stream discharge (Socolow *et al.* 1999 and 2000) were analyzed to estimate hydrological conditions during the water quality sampling events. This review was conducted to estimate the streamflow condition in relation to the 7-day, 10-year (7Q10) low flow (the annual minimum 7-day mean discharge for a river over a 10-year recurrence interval). Additionally, this review was used to determine whether the fecal coliform bacteria data were representative of "wet" or "dry weather" sampling conditions.

USGS Gage # 01110000 is located in North Grafton on the Quinsigamond River. Flow at this gage is affected by regulation by Lake Quinsigamond 2.3 miles upstream and by other ponds upstream. USGS Gage # 01110500 is located in Northbridge on the Blackstone River. Flow at this gage is regulated by mills and reservoirs upstream as well as by diversions from the Nashua River Basin and at times from Quabbin Reservoir for the municipal supply of Worcester.

Survey conditions are described below for each DWM sampling event reviewed for the assessment.

12 May 1998: Precipitation was reported at both the Douglas and Worcester precipitation stations (Table B2). Precipitation greater than one inch was reported at both gages two days prior to the sampling event. Daily precipitation at the Worcester gage ranged from 1.18 to 0.03 inches during the five days prior to the water quality sampling event. At the Douglas gage precipitaion ranged from 1.31 to 0.0 inches during the five days prior with 0.34 inches falling on the sampling date. As depicted in Figure B4, stream flow responded to the storm events. Due to regulation from Lake Quinsigamond and other ponds upstream, the North Grafton gage showed less response than the Northbridge gage. Discharge on the Quinsigamond River was approximately 600 times greater than the 7-day, 10-year (7Q10) low flow estimates (USGS 1998). The Blackstone River responded similarly with flow approximately 31 times higher than the low flow estimates (Table B3). The data are considered representative of wet weather conditions.

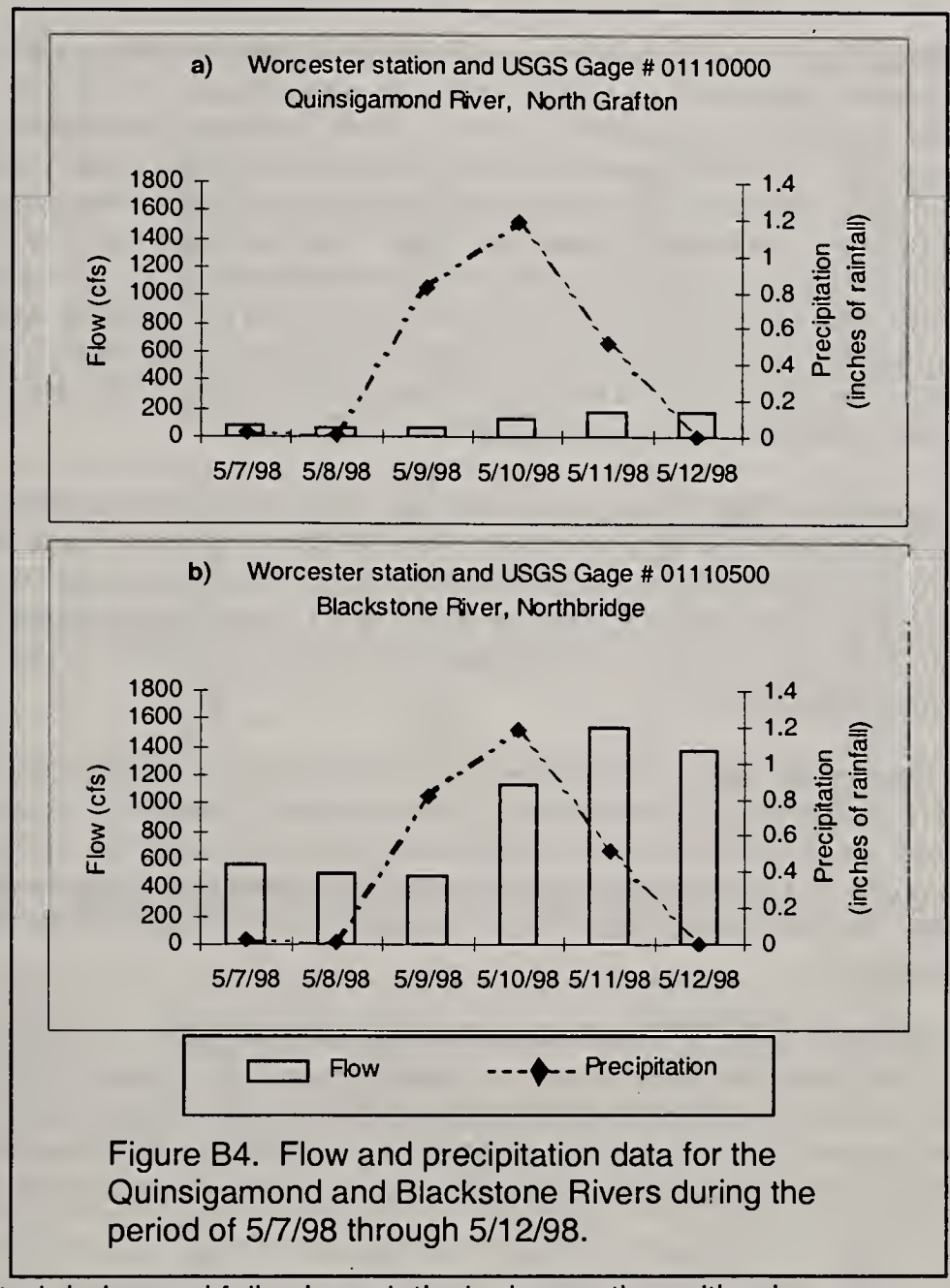


Figure B4. Flow and precipitation data for the Quinsigamond and Blackstone Rivers during the period of 5/7/98 through 5/12/98.

9 June 1998: This survey was conducted during and following relatively dry weather with minor precipitation recorded just at the Worcester gage on 7-8 June (Table B2). Streamflows recorded for this event were below the monthly averages for June 1998 (Table B3). Quinsigamond River flows were below the period of record monthly mean. Streamflows on the Quinsigamond and Blackstone Rivers respectively were 81 to six times higher than the 7Q10 low flow estimates with the monthly average discharges 277 to 13 times higher than the 7Q10 low flow estimates (USGS 1998). Data collected during this survey are interpreted as being representative of dry weather.

8 July 1998: This survey was conducted during and following relatively dry weather with minor precipitation recorded at the Worcester station on the sampling date (Table B2). Streamflows on the Quinsigamond River on this date were above both the July 1998 monthly mean and the period of record monthly averages. Discharges were 142 times higher than the 7Q10 low flow estimates on the Quinsigamond River (USGS 1998). However, on the Blackstone River, streamflows were below the monthly mean for July 1998 and above the POR monthly averages (Table B3). Discharge was four times higher than the 7Q10 estimates for the Blackstone River (USGS 1998). These data are representative of dry weather conditions.

10 July 1998: This survey was conducted during and following relatively dry weather conditions with minor precipitation reported during the five day period preceeding the sampling event (Table B2). Streamflow of the Quinsigamond River was above the monthly mean for July 1998 and above the POR monthly averages (Table B3). Streamflow of the Blackstone River was below the monthly mean and above the

POR monthly averages (Table B3). Discharges on both the Quinsigamond and Blackstone Rivers were higher (123 and four times, respectively) than the 7Q10 low flow estimates (USGS 1998). Data collecetd during this survey are interpreted as being representative of dry weather conditions.

4 August 1998: Four days prior to the sampling event, rain was recorded at both the Douglas and Worcester stations (0.43 and 0.68 inches, respectively) (Table B2). Streamflows on the Quinsigamond River increased slightly from 12 cfs to 18 cfs, and then receeded to prestorm levels by the sampling date (Table B3). On the Blackstone River, USGS notes that the records are poor from June 28 to Sept. 30 due to unusual regulation thus making interpretation difficult. Discharges on the Quinsigamond.River were greater than the monthly mean for August 1998 and less than the POR monthly mean (Table B3). Streamflows on the Quinsigamond River were 35 times higher than the 7Q10 low flow estimates (USGS 1998). Discharges on the Blackstone River on the sample date were greater than the monthly mean for August 1998 and less than the POR monthly mean. Streamflows on the Blackstone were two times higher than the 7Q10 low flow estimates (USGS 1998). The data (interpreted with caution) are considered as being representative of dry weather conditions.

2 September 1998: This survey was conducted and following relatively dry weather with 0.07 inches of rain recorded at the Worcester gage on the sampling date (Table B2). Streamflows on the sampling date were above the monthly means for September and were below the POR monthly mean (Table B3). Discharges were one (Blackstone River) to 14 times (Quinsigamond River) higher than the 7Q10 low flow estimates (USGS 1998). Data collected during this survey are interpreted as representative of dry weather conditions.

30 September 1998: This survey was conducted during and following relatively dry weather conditions with minor precipitation recorded at both stations (Table B2). Streamflows on the sampling date were above the monthly means for September and were below the POR monthly mean (Table B3). Discharges were one to 13 times higher than the 7Q10 low flow estimates for the Blackstone and Quinsigamond Rivers respectively (USGS 1998). These data are interpreted as being representative of dry weather conditions.

27 October 1998: This survey was conducted during and following relatively dry weather conditions (Table B2). Streamflows were below the monthly means for October 1998 and below the POR monthly mean (Table B3). Discharges on the sample date were two times higher than the 7Q10 low flow estimates on the Blackstone River and and 23 times higher than the 7Q10 estimates on the Quinsigamond River (USGS 1998). Data are interpreted as being representative of dry weather conditions.

**Table B2**. 1998 MA DEM Precipitation Data Summary (MA DEM 1998).

Blackstone River Basin Survey
Precipitation Data Summary (reported in inches of rain)

| Survey Dates | 5 Days Prior | 4 Days Prior | 3 Days Prior | 2 Days Prior | 1 Day Prior | Sample Date |
|---|---|---|---|---|---|---|
| Worcester | | | | | | |
| 5/12/98 | 0.03 | 0.01 | 0.82 | 1.18 | 0.52 | 0.0 |
| 6/9/98 | 0.0 | 0.0 | 0.0 | 0.09 | 0.30 | 0.0 |
| 7/8/98 | 0.0 | 0.0 | 0.01 | 0.0 | 0.01 | 0.16 |
| 7/10/98 | 0.01 | 0.0 | 0.01 | 0.16 | 0.0 | 0.0 |
| 8/4/98 | * | 0.68 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9/2/98 | 0.0 | 0.01 | 0.01 | 0.01 | 0.0 | 0.07 |
| 9/30/98 | 0.0 | 0.01 | 0.10 | 0.0 | 0.0 | 0.11 |
| 10/27/98 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Douglas Station # 511 | | | | | | |
| 5/12/98 | 0.9 | 0.0 | 0.0 | 1.31 | 0.77 | 0.34 |
| 6/9/98 | 0.0 | 0.0 | 0.0 | 0. 0 | 0.0 | 0.0 |
| 7/8/98 | 0.0 | 0.0 | 0.02 | 0.0 | 0.0 | 0.02 |
| 7/10/98 | 0.02 | 0.0 | 0.0 | 0.02 | 0.0 | 0.0 |
| 8/4/98 | 0.0 | 0.43 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9/2/98 | 0.0 | 0.0 | 0.04 | 0.0 | 0.0 | 0.0 |
| 9/30/98 | 0.0 | 0.0 | 0.06 | 0.03 | 0.0 | 0.0 |
| 10/27/98 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

* trace amount of precipitation noted

**Table B3**. 1998 USGS Flow Data Summary (Socolow *et al.* 1999 and 2000).

Blackstone River Basin Survey
USGS Flow Data Summary (reported in cfs)

| Survey Dates | 5 Days Prior | 4 Days Prior | 3 Days Prior | 2 Days Prior | 1 Day Prior | Sample Date | Monthly Mean | POR* Monthly Mean |
|---|---|---|---|---|---|---|---|---|
| Quinsigamond River at North Grafton, MA (Provisional 7Q10 = 0.308cfs (USGS 1998)) | | | | | | | | |
| Gage #01110000 | | | | | | | | |
| 5/12/98 | 74 | 68 | 64 | 122 | 173 | 185 | 71.6 | 52.6 |
| 6/9/98 | 46 | 37 | 30 | 26 | 26 | 25 | 85.5 | 38.1 |
| 7/8/98 | 97 | 79 | 69 | 58 | 49 | 44 | 35.5 | 20.0 |
| 7/10/98 | 69 | 58 | 49 | 44 | 41 | 38 | 35.5 | 20.0 |
| 8/4/98 | 12 | 15 | 18 | 15 | 13 | 11 | 8.41 | 17.5 |
| 9/2/98 | 8.3 | 7.2 | 6.1 | 5.8 | 5.1 | 4.4 | 3.91 | 15.3 |
| 9/30/98 | 8.5 | 7.6 | 7.4 | 7.1 | 5.3 | 4.3 | 3.91 | 15.3 |
| 10/27/98 | 13 | 11 | 9.3 | 8.6 | 7.9 | 7.2 | 20.2 | 20.7 |
| Blackstone River at Northbridge, MA (Provisional 7Q10 = 43.649 cfs (USGS 1998)) | | | | | | | | |
| Gage #01110500** | | | | | | | | |
| 5/12/98 | 570 | 510 | 494 | 1130 | 1540 | 1380 | 508 | 310 |
| 6/9/98 | 266 | 222 | 218 | 251 | 246 | 263 | 587 | 231 |
| 7/8/98 | 571 | 454 | 346 | 290 | 231 | 210 | 232 | 145 |
| 7/10/98 | 346 | 290 | 231 | 210 | 200 | 183 | 232 | 145 |
| 8/4/98 | 112 | 154 | 89 | 61 | 83 | 110 | 95.5 | 142 |
| 9/2/98 | 76 | 74 | 73 | 74 | 74 | 73 | 88.2 | 144 |
| 9/30/98 | 78 | 92 | 143 | 94 | 71 | 76 | 88.2 | 144 |
| 10/27/98 | 125 | 113 | 116 | 184 | 149 | 122 | 178 | 165 |

* Period of Record (POR for Northbridge gage is intermittent)
** USGS notes that records for Nov. 24 to Jan 7 and June 28 to Sept. 30 are poor for this

**Table B4.** 1998 DEP DWM Blackstone River Basin stream discharge measurements.

| Time (24hr) | Collecting Agency | Sampling Technique | Velocity (fps) | Discharge (cfs) |
|---|---|---|---|---|
| **BLACKSTONE RIVER** | | | | |
| Station: BLK01 | | | | |
| Description: approximately 50 meters downstream (south) of Millbury Street bridge, Worcester | | | | |
| 06/09/98 9:30 | DEP | Swoffer 2100 | 0.74 | 39.4 |
| 07/08/98 9:00 | DEP | Swoffer 2100 | 1.3 | 57.8 |
| 08/04/98 9:15 | DEP | Swoffer 2100 | -- | -- |
| **WEST RIVER** | | | | |
| Station: WR09 | | | | |
| Description: approximately 100 meters upstream (northwest) of West River Street, Upton | | | | |
| 09/02/98 13:15 | DEP | Swoffer 2100 | 0.20 | 2.30 |
| **WEST RIVER** | | | | |
| Station: WR12 | | | | |
| Description: approximately 20 meters downstream (southeast) of Glen Avenue (approximately 10 meters upstream (northwest) of Warren Brook confluence), Upton | | | | |
| 09/02/98 9:30 | DEP | Swoffer 2100 | 0.30 | 1.27 |
| **CENTER BROOK** | | | | |
| Station: WR20 | | | | |
| Description: approximately 30 meters downstream (south) of Mendon Street, Upton | | | | |
| 09/02/98 10:40 | DEP | Swoffer 2100 | 0.34 | 0.72 |
| **MIDDLE RIVER** | | | | |
| Station: TB01 | | | | |
| Description: outlet Coes Pond (above dam structure), Worcester | | | | |
| 06/09/98 13:10 | DEP | Swoffer 2100 | 0.31 | 4.65 |
| 07/08/98 9:30 | DEP | Swoffer 2100 | 0.33 | 5.19 |
| 08/04/98 9:55 | DEP | Swoffer 2100 | 0.22 | 0.55 |
| **KETTLE BROOK** | | | | |
| Station: KB09 | | | | |
| Description: approximately 2 meters downstream (west) of Auburn Street bridge, Leicester | | | | |
| 07/08/98 11:05 | DEP | Swoffer 2100 | 0.39 | 2.06 |
| **KETTLE BROOK** | | | | |
| Station: KB10 | | | | |
| Description: approximately 5 meters downstream (south) of Earle Street, Leicester | | | | |
| 07/08/98 12:15 | DEP | Swoffer 2100 | 0.56 | 1.98 |
| **Unnamed and/or Undefined SARIS** | | | | |
| Station: KB02D | | | | |
| Description: at small dam (where USGS gage is) downstream (northwest) of Webster Street and outlet of Leesville Pond (not at large Leesville Pond dam), Worcester | | | | |
| 08/04/98 ** | DEP | Swoffer 2100 | 2.7 | 5.77 |
| **Unnamed and/or Undefined SARIS** | | | | |
| Station: KB02 | | | | |
| Description: outlet of Leesville Pond downstream (northwest) of Webster Street (at first bend downstream of both large and small dams), Worcester | | | | |
| 06/09/98 11:25 | DEP | Swoffer 2100 | 1.1 | 21.2 |
| 07/08/98 2:25 | DEP | Swoffer 2100 | 1.5 | 33.4 |
| 08/04/98 11:30 | DEP | Swoffer 2100 | 0.83 | 5.42 |
| **DARK BROOK** | | | | |
| Station: RB01 | | | | |
| Description: upstream (south) of Route 12 (downstream (north) of Auburn Pond dam), Auburn | | | | |
| 07/08/98 3:20 | DEP | Swoffer 2100 | 1.3 | 13.0 |
| 07/08/98 12:00 | DEP | Swoffer 2100 | 1.4 | 13.5 |
| 08/04/98 1:50 | DEP | Swoffer 2100 | 0.36 | 2.16 |
| **BEAVER BROOK** | | | | |
| Station: BB01 | | | | |
| Description: upstream (west) of Park Avenue (Routes 9 & 12) and east of Beaver Brook Parkway, Worcester | | | | |
| 06/09/98 13:47 | DEP | Swoffer 2100 | 0.12 | 1.81 e |
| 07/08/98 11:10 | DEP | Swoffer 2100 | 0.17 | 3.17 |

** = missing/censored data -- = no data e = flow estimated see field sheet for details

## STREAM WATER QUALITY MONITORING

The Hydrolab® *in-situ* results are provided in Table B5. Discrete water sampling data includes physico-chemical (Table B6) and bacterial data (Table B7). DEP DWM water quality data is managed and maintained in the *Water Quality Data Access Database*.

**Table B5.** 1998 DEP DWM Blackstone River Basin, *in-situ* Hydrolab® data.

| | | Time (24hr) | Measurement Depth (m) | Temp (°C) | pH (SU) | Cond (uS/cm) | TDS (g/l) | DO (mg/l) | SAT (%) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| **BLACKSTONE RIVER** | | | | | | | | | | |
| Station: BLK01, Mile Point: 29.5 | | | | | | | | | | |
| Description: upstream/north at the southern most crossing of Millbury Street, Worcester. | | | | | | | | | | |
| 51-0028 | 06/09/98 | 09:48 | 0.6 | 15.7 | 7.1 | 377 | 0.2 | 8.8 | 86 | -- |
| 51-0038 | 07/08/98 | 11:40 | <0.3 | 22.0 | 7.1 | 319 | 0.2 | 8.6 | 97 | 5 |
| 51-0056 | 08/04/98 | 09:44 | 0.8 | 21.6 | 7.1 | 487 | 0.3 | 8.2 | 91 | -- |
| **BLACKSTONE RIVER** | | | | | | | | | | |
| Station: BLK02, Mile Point: 27.6 | | | | | | | | | | |
| Description: upstream/northwest at McCracken Road, Millbury. | | | | | | | | | | |
| 51-0037 | 07/08/98 | 13:41 | 0.5 | 21.0 | 6.8 | 453 | 0.3 | 8.2 | 90 | -- |
| **BLACKSTONE RIVER/Singing Dam Impoundment** | | | | | | | | | | |
| Station: 669, Mile Point: 23.8 | | | | | | | | | | |
| Description: approximately 170 feet upstream of Singing Dam, Blackstone Street, Sutton. | | | | | | | | | | |
| 51-0058 | 08/06/98 | 18:23 | ** | ** | ** | ** | ** | ** | ** | ** |
| 51-0060 | 08/07/98 | 05:28 | ** | ** | ** | ** | ** | ** | ** | ** |
| **BLACKSTONE RIVER/Fisherville Pond** | | | | | | | | | | |
| Station: 668, Mile Point: 20.5 | | | | | | | | | | |
| Description: Fisherville Dam abutment, east side near gate structure, Grafton. | | | | | | | | | | |
| 51-0059 | 08/06/98 | 17:46 | ** | ** | ** | ** | ** | ** | ** | ** |
| 51-0061 | 08/07/98 | 05:54 | ** | ** | ** | ** | ** | ** | ** | ** |
| **BLACKSTONE RIVER** | | | | | | | | | | |
| Station: BLK07-A, Mile Point: 17.5 | | | | | | | | | | |
| Description: upstream/northwest at Sutton Street, Northbridge. | | | | | | | | | | |
| 51-0036 | 07/08/98 | 12:13 | 0.4 | 22.1 | 7.2 | 357 | 0.2 | 8.5 | 96 | -- |
| **BLACKSTONE RIVER/Rice City Pond** | | | | | | | | | | |
| Station: 670, Mile Point: 11.8 | | | | | | | | | | |
| Description: at sluice way north of East Hartford Avenue, Uxbridge. | | | | | | | | | | |
| 51-0062 | 08/07/98 | 06:22 | ** | ** | ** | ** | ** | ** | ** | ** |
| **BLACKSTONE RIVER** | | | | | | | | | | |
| Station: BLK12A, Mile Point: 3.4 | | | | | | | | | | |
| Description: upstream/west of Central Street, Millville. | | | | | | | | | | |
| 51-0035 | 07/08/98 | 10:21 | 0.4 | 21.6 | 6.8 | 226 | 0.1 | 7.6 | 85 | -- |
| **BLACKSTONE RIVER** | | | | | | | | | | |
| Station: 667, Mile Point: -14.2 | | | | | | | | | | |
| Description: Approximately 100 feet upstream of Route 114 bridge, Central Falls, Rhode Island. | | | | | | | | | | |
| 51-0057 | 08/06/98 | 16:30 | ** | ** | ** | ** | ** | ** | ** | ** |
| 51-0063 | 08/07/98 | 07:26 | ** | ** | ** | ** | ** | ** | ** | ** |
| **MILL RIVER** | | | | | | | | | | |
| Station: BLK15-1, Mile Point: 2.1 | | | | | | | | | | |
| Description: upstream/northwest of Summer Street (Park Street), Blackstone. | | | | | | | | | | |
| 51-0032 | 07/08/98 | 10:56 | 0.4 | 20.2 | 6.6 | 155 | 0.10 | 8.0 | 87 | -- |

** = censored data, -- = no data

**Table B5.** Continued. 1998 DEP DWM Blackstone River Basin, *in-situ* Hydrolab® data.

| | | Time (24hr) | Measurement Depth (m) | Temp (°C) | pH (SU) | Cond (uS/cm) | TDS (g/l) | DO (mg/l) | SAT (%) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| **WEST RIVER** | | | | | | | | | | |
| Station: WR12, Mile Point: 10 | | | | | | | | | | |
| Description: upstream/west of Glen Avenue, Upton. | | | | | | | | | | |
| 51-0074 | 09/02/98 | 09:15 | <0.3 | 20.4 | 7.0 | 197 | 0.1 | 8.6 | 94 | -- |
| **WEST RIVER** | | | | | | | | | | |
| Station: WR10, Mile Point: 8.6 | | | | | | | | | | |
| Description: downstream/south at Pleasant Street, Upton. | | | | | | | | | | |
| 51-0073 | 09/02/98 | 10:03 | <0.3 | 20.5 | 6.2 | 374 | 0.2 | 4.1 | 45 | -- |
| **WEST RIVER** | | | | | | | | | | |
| Station: WR03, Mile Point: 3.3 | | | | | | | | | | |
| Description: upstream/north, down the bank at East Hartford Street bridge, Uxbridge. | | | | | | | | | | |
| 51-0072 | 09/02/98 | 11:41 | <0.3 | 20.7 | 6.6 | 201 | 0.1 | 7.7 | 85 | -- |
| **CENTER BROOK** | | | | | | | | | | |
| Station: WR20, Mile Point: 1.6 | | | | | | | | | | |
| Description: upstream/northeast of Mendon Street, Upton | | | | | | | | | | |
| 51-0075 | 09/02/98 | 10:47 | <0.3 | 15.9 | 6.6 | 163 | 0.1 | 8.6 | 86 | -- |
| **MUMFORD RIVER** | | | | | | | | | | |
| Station: BLK09-8, Mile Point: 11.3 | | | | | | | | | | |
| Description: upstream/north at Potter Road, Douglas. | | | | | | | | | | |
| 51-0031 | 07/08/98 | 09:25 | 0.4 | 20.9 | 6.3 | 41 | 0.03 | 8.7 | 95 | -- |
| **Unnamed and/or Undefined SARIS/Coes Pond** | | | | | | | | | | |
| Station: TB01, Mile Point: 0 | | | | | | | | | | |
| Description: upstream of outlet of Coes Pond, upstream/northwest of Park Avenue, Worcester. | | | | | | | | | | |
| 51-0025 | 06/09/98 | 11:14 | 0.3 | 17.9 | ** | 204 | 0.1 | 8.3 | 85 | -- |
| 51-0044 | 07/08/98 | 09:11 | <0.3 | 22.8 | 6.6 | 158 | 0.1 | 4.5 | 51 | ** |
| 51-0050 | 08/04/98 | 11:27 | 0.5 | 25.6 | 8.4 | 181 | 0.1 | 9.8 | 116 | -- |
| **MIDDLE RIVER** | | | | | | | | | | |
| Station: Middle Riv, Mile Point: 2.7 | | | | | | | | | | |
| Description: downstream/west off Mill Street bridge, Worcester. | | | | | | | | | | |
| 51-0048 | 07/10/98 | 15:44 | 0.5 | 21.1 | 6.8 | 253 | 0.2 | 7.7 | 85 | -- |
| **MIDDLE RIVER** | | | | | | | | | | |
| Station: BLK00, Mile Point: 0.1 | | | | | | | | | | |
| Description: upstream/west at the northern most crossing of Millbury Street, Worcester. Sampled from bridge. | | | | | | | | | | |
| 51-0027 | 06/09/98 | 10:12 | <0.3 | 16.1 | 7.2 | 279 | 0.2 | 9.4 | 93 | -- |
| 51-0039 | 07/08/98 | 11:58 | <0.3 | 22.5 | 7.2 | 233 | 0.1 | 8.7 | 99 | ** |
| 51-0049 | 08/04/98 | 09:08 | 0.4 | 21.8 | 7.2 | 352 | 0.2 | 8.1 | 90 | -- |
| **KETTLE BROOK** | | | | | | | | | | |
| Station: KB10, Mile Point: 8 | | | | | | | | | | |
| Description: upstream/north of Earle Street, Leicester. Wade in sample. | | | | | | | | | | |
| 51-0047 | 07/08/98 | 10:01 | ** | ** | ** | ** | ** | ** | ** | ** |
| **KETTLE BROOK** | | | | | | | | | | |
| Station: KB09, Mile Point: 5.5 | | | | | | | | | | |
| Description: upstream/west of Auburn Street, Leicester. Wade in sample. | | | | | | | | | | |
| 51-0046 | 07/08/98 | 09:37 | <0.3 | 19.0 | 6.6 | 122 | 0.08 | 8.5 | 90 | 4 |
| **Unnamed and/or Undefined SARIS** | | | | | | | | | | |
| Station: KB02, Mile Point: 0.08 | | | | | | | | | | |
| Description: Downstream from the outlet Leesville Pond, upstream of Oxford Street, Worcester. | | | | | | | | | | |
| 51-0026 | 06/09/98 | 10:37 | 0.4 | 17.5 | ** | 258 | 0.2 | 8.5 | 87 | -- |
| 51-0041 | 07/08/98 | 10:41 | <0.3 | 23.2 | 6.7 | 208 | 0.1 | 7.7 | 88 | ** |
| 51-0051 | 08/04/98 | 11:01 | 1.2 | 23.1 | 7.1 | 314 | 0.2 | 8.1 | 92 | -- |

** = censored data, -- = no data

**Table B5.** Continued. 1998 DEP DWM Blackstone River Basin, *in-situ* Hydrolab® data.

| | | Time (24hr) | Measurement Depth (m) | Temp (°C) | pH (SU) | Cond (uS/cm) | TDS (g/l) | DO (mg/l) | SAT (%) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| **DARK BROOK** | | | | | | | | | | |
| Station: RB01, Mile Point: 1 | | | | | | | | | | |
| Description: downstream/north of Route 12, Auburn. | | | | | | | | | | |
| 51-0040 | 07/08/98 | 11:11 | <0.3 | 22.1 | 6.6 | 210 | 0.1 | 7.6 | 86 | ** |
| 51-0054 | 08/04/98 | 10:26 | 0.5 | 22.5 | 6.9 | 390 | 0.3 | 8.5 | 96 | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | | | | | |
| Station: BB04, Mile Point: 0.5 | | | | | | | | | | |
| Description: upstream/north of Assumption College driveway (upstream of small pond), Worcester. Driveway is unnamed road east of Salisbury Street. (urban/intermittent/culverted stream, mile point is estimated from best fit line) | | | | | | | | | | |
| 51-0020 | 05/12/98 | 12:21 | <0.3 | 12.1 | 6.7 | 205 | 0.1 | 9.9 | 90 | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | | | | | |
| Station: BB03, Mile Point: 0.1 | | | | | | | | | | |
| Description: upstream/north of Flagg Street, Worcester. | | | | | | | | | | |
| 51-0019 | 05/12/98 | 11:40 | <0.3 | 10.8 | 6.6 | 174 | 0.1 | 10.5 | 93 | -- |
| **BEAVER BROOK** | | | | | | | | | | |
| Station: BB01, Mile Point: 0.1 | | | | | | | | | | |
| Description: upstream/northwest at Park Avenue, Worcester. | | | | | | | | | | |
| 51-0017 | 05/12/98 | 10:31 | 0.3 | 10.8 | 6.3 | 267 | 0.2 | 9.8 | 87 | -- |
| 51-0024 | 06/09/98 | 11:00 | <0.3 | 14.1 | 6.8 | 340 | 0.2 | 6.9 | 65 | -- |
| 51-0045 | 07/08/98 | 08:55 | <0.3 | 15.9 | 6.6 | 341 | 0.2 | 7.9 | 79 | ** |
| 51-0055 | 08/04/98 | 11:49 | 0.5 | 17.2 | 6.8 | 379 | 0.2 | 7.6 | 77 | -- |

** = censored data, -- = no data

**Table B6.** 1998 DEP DWM Blackstone River Basin, instream physico-chemical data. All units in mg/L unless otherwise noted.

| | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos) | Chloride | Suspended Solids | Total Petroleum Hydrocarbons | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP04E, Mile Point: 4.43 | | | | | | | | | | | | | |
| Description: West Boylston Drive, Worcester. Eastern most manhole directly outside Norton property fence. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0007 | 05/19/98 | 10:55 | -- | 78 | 480 | -- | 4.8 | <0.78 | 3.9 | -- | 0.05 | 0.93 | 0.05 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP04W, Mile Point: 4.42 | | | | | | | | | | | | | |
| Description: West Boylston Drive, Worcester. Western most manhole directly outside Norton property fence. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0008 | 05/19/98 | 11:00 | -- | 38 | 300 | -- | 8.4 | <0.78 | 7.3 | -- | <0.02 | 0.08 | 0.04 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP03E, Mile Point: 3.82 | | | | | | | | | | | | | |
| Description: Harr Ford, 100 Gold Star Boulevard, Worcester. Manhole located under cars in parking lot. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0009 | 05/19/98 | 10:30 | -- | 83 | 510 | -- | 4.8 | <0.78 | 4.1 | -- | 0.06 | 0.78 | 0.06 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP03W, Mile Point: 3.8 | | | | | | | | | | | | | |
| Description: Harr Ford, 100 Gold Star Boulevard, Worcester. Manhole located under cars in parking lot. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0010 | 05/19/98 | 10:15 | -- | 69 | 470 | -- | 6.0 | <0.78 | 5.8 | -- | 0.04 | 0.45 | 0.06 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP02E, Mile Point: 3.4 | | | | | | | | | | | | | |
| Description: Glennie Street at Percy's back driveway entrance, Worcester. Eastern most manhole literally in driveway. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0011 | 05/19/98 | 9:55 | -- | 91 | 610 | -- | 3.2 | <0.78 | 3.3 | -- | 0.08 | 0.98 | 0.06 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP02W, Mile Point: 3.3 | | | | | | | | | | | | | |
| Description: Glennie Street at Percy's back driveway entrance, Worcester. Western most manhole in parking lot. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0012 | 05/19/98 | 9:35 | -- | 75 | 520 | -- | 6.0 | <0.78 | 5.5 | -- | 0.05 | 0.62 | 0.05 |
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | |
| Station: SP01E, Mile Point: 3 | | | | | | | | | | | | | |
| Description: Tire Warehouse, 195 Grove Street, Worcester. Sampled off bridge, the eastern most pipe where it emerged from underground. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | |
| 51-0013 | 05/19/98 | 11:15 | -- | 88 | 580 | -- | 4.6 | <0.78 | 3.9 | -- | 0.06 | 0.88 | 0.06 |

** = missing/censored data -- = no data

**Table B6.** Continued. 1998 DEP DWM Blackstone River Basin, instream physico-chemical data. All units in mg/L unless otherwise noted.

| | | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos) | Chioride | Suspended Solids | Total Petroleum Hydrocarbons | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unnamed and/or Undefined SARIS locally known as Mill Brook** | | | | | | | | | | | | | | |
| Station: SP01W, Mile Point: 3 | | | | | | | | | | | | | | |
| Description: Tire Warehouse, 195 Grove Street, Worcester. Sampled off bridge, the western most pipe where it emerged from underground. (Culverted water locally called Mill Brook, tributary to Blackstone River thru Salisbury Pond.) | | | | | | | | | | | | | | |
| 51-0014 | 51-0015 | 05/19/98 | 11:20 | -- | 71 | 500 | -- | 6.0 | <0.78 | 6.0 | -- | 0.04 | 0.46 | 0.07 |
| 51-0015 | 51-0014 | 05/19/98 | 11:20 | -- | 71 | 500 | -- | 6.2 | <0.78 | 5.6 | -- | 0.10 | 0.46 | 0.07 |
| **BLACKSTONE RIVER** | | | | | | | | | | | | | | |
| Station: BLK01, Mile Point: 29.5 | | | | | | | | | | | | | | |
| Description: upstream/north at the southern most crossing of Millbury Street, Worcester. | | | | | | | | | | | | | | |
| 51-0028 | 51-0029 | 06/09/98 | 9:48 | 36 | 70 | -- | 83 | 2.2 | -- | 2.4 | ** | 0.04 | 0.37 | 0.06 |
| 51-0029 | 51-0028 | 06/09/98 | 9:48 | 36 | 71 | -- | 79 | 2.4 | -- | 2.9 | ** | 0.05 | 0.37 | 0.06 |
| 51-0038 | | 07/08/98 | 11:40 | 35 | 55 | 320 | 64 | 1.5 | -- | 2.4 | 0.43 | 0.03 | 0.36 | 0.06 |
| 51-0056 | | 08/04/98 | 9:30 | 47 | 77 | -- | 94 | <1.0 | -- | 2.9 | -- | 0.09 | 0.58 | 0.04 |
| **BLACKSTONE RIVER** | | | | | | | | | | | | | | |
| Station: BLK02, Mile Point: 27.6 | | | | | | | | | | | | | | |
| Description: upstream/northwest at McCracken Road, Millbury. | | | | | | | | | | | | | | |
| 51-0037 | | 07/08/98 | 1:40 | 41 | 67 | 460 | 86 | 2.5 | -- | 2.0 | 0.81 | 0.20 | 2.3 | 0.34 |
| **BLACKSTONE RIVER** | | | | | | | | | | | | | | |
| Station: BLK07-A, Mile Point: 17.5 | | | | | | | | | | | | | | |
| Description: upstream/northwest at Sutton Street, Northbridge. | | | | | | | | | | | | | | |
| 51-0036 | | 07/08/98 | 12:13 | 32 | 51 | 360 | 68 | 6.9 | -- | 2.3 | 0.75 | 0.21 | 2.0 | 0.34 |
| **BLACKSTONE RIVER** | | | | | | | | | | | | | | |
| Station: BLK12A, Mile Point: 3.4 | | | | | | | | | | | | | | |
| Description: upstream/west of Central Street, Millville. | | | | | | | | | | | | | | |
| 51-0035 | | 07/08/98 | 10:21 | 18 | 33 | 230 | 43 | 5.7 | -- | 1.8 | 0.50 | 0.06 | 1.1 | 0.23 |
| **MILL RIVER** | | | | | | | | | | | | | | |
| Station: BLK15-1, Mile Point: 2.1 | | | | | | | | | | | | | | |
| Description: upstream/northwest of Summer Street (Park Street), Blackstone. | | | | | | | | | | | | | | |
| 51-0032 | 51-0033 | 07/08/98 | 10:57 | 14 | 21 | 160 | 31 | 2.7 | -- | 2.3 | 0.43 | <0.02 | 0.29 | 0.07 |
| 51-0033 | 51-0032 | 07/08/98 | 10:57 | 14 | 21 | 160 | 33 | 2.5 | -- | 2.2 | 0.40 | <0.02 | 0.40 | 0.07 |
| **WEST RIVER** | | | | | | | | | | | | | | |
| Station: WR12, Mile Point: 10 | | | | | | | | | | | | | | |
| Description: upstream/west of Glen Avenue, Upton | | | | | | | | | | | | | | |
| 51-0074 | 51-0077 | 09/02/98 | 9:16 | 18 | 24 | -- | 42 | 2.0 | -- | 2.8 | 0.46 | <0.02 | 0.09 | 0.04 |
| 51-0077 | 51-0074 | 09/02/98 | 9:16 | 17 | 24 | -- | 42 | 2.2 | -- | 2.7 | 0.44 | 0.02 | 0.10 | 0.04 |

** = missing/censored data -- = no data

**Table B6.** Continued. 1998 DEP DWM Blackstone River Basin, instream physico-chemical data. All units in mg/L unless otherwise noted.

| | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos) | Chloride | Suspended Solids | Total Petroleum Hydrocarbons | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WEST RIVER** | | | | | | | | | | | | | |
| Station: WR10, Mile Point: 8.6 | | | | | | | | | | | | | |
| Description: downstream/south at Pleasant Street, Upton. | | | | | | | | | | | | | |
| 51-0073 | 09/02/98 | 10:00 | 16 | 32 | -- | 91 | 1.8 | -- | 2.5 | 0.52 | 0.06 | 0.96 | 0.19 |
| **WEST RIVER** | | | | | | | | | | | | | |
| Station: WR03, Mile Point: 3.3 | | | | | | | | | | | | | |
| Description: upstream/north, down the bank at East Hartford Street bridge, Uxbridge. | | | | | | | | | | | | | |
| 51-0072 | 09/02/98 | 11:40 | 17 | 23 | -- | 43 | 3.8 | -- | 2.0 | 0.42 | <0.02 | 0.05 | 0.06 |
| **CENTER BROOK** | | | | | | | | | | | | | |
| Station: WR20, Mile Point: 1.6 | | | | | | | | | | | | | |
| Description: upstream/northeast of Mendon Street, Upton. | | | | | | | | | | | | | |
| 51-0075 | 09/02/98 | 11:00 | 15 | 22 | -- | 32 | <1.0 | -- | 1.6 | 0.18 | <0.02 | 0.57 | 0.02 |
| **MUMFORD RIVER** | | | | | | | | | | | | | |
| Station: BLK09-8, Mile Point: 11.3 | | | | | | | | | | | | | |
| Description: upstream/north at Potter Road, Douglas. | | | | | | | | | | | | | |
| 51-0031 | 07/08/98 | 9:25 | 4.0 | 7.9 | 59 | 4.0 | <1.0 | -- | 1.2 | 0.21 | <0.02 | 0.06 | 0.01 |
| **Unnamed and/or Undefined SARIS/Coes Pond** | | | | | | | | | | | | | |
| Station: TB01, Mile Point: 0 | | | | | | | | | | | | | |
| Description: upstream of outlet of Coes Pond, upstream/northwest of Park Avenue, Worcester. | | | | | | | | | | | | | |
| 51-0025 | 06/09/98 | 11:14 | 19 | 32 | -- | 42 | <1.0 | -- | 1.3 | ** | <0.02 | <0.02 | 0.02 |
| 51-0044 | 07/08/98 | 9:12 | 18 | 26 | 160 | 29 | <1.0 | -- | 1.7 | 0.79 | 0.05 | 0.03 | 0.04 |
| 51-0050 | 08/04/98 | 11:27 | 22 | 29 | -- | 33 | 2.2 | -- | 4.5 | -- | <0.02 | <0.02 | 0.06 |
| **MIDDLE RIVER** | | | | | | | | | | | | | |
| Station: BLK00, Mile Point: 0.1 | | | | | | | | | | | | | |
| Description: upstream/west at the northern most crossing of Millbury Street, Worcester. | | | | | | | | | | | | | |
| 51-0027 | 06/09/98 | 10:12 | 29 | 54 | -- | 56 | 3.0 | -- | 2.4 | ** | 0.02 | 0.25 | 0.05 |
| 51-0039 | 07/08/98 | 11:58 | 25 | 42 | 240 | 47 | 1.4 | -- | 2.2 | 0.39 | <0.02 | 0.26 | 0.06 |
| 51-0049 | 08/04/98 | 9:00 | 40 | 63 | -- | 70 | 3.5 | -- | 3.6 | -- | 0.07 | 0.37 | 0.04 |
| **KETTLE BROOK** | | | | | | | | | | | | | |
| Station: KB10, Mile Point: 8 | | | | | | | | | | | | | |
| Description: upstream/north of Earle Street, Leicester. | | | | | | | | | | | | | |
| 51-0047 | 07/08/98 | 10:01 | 7.0 | 15 | 110 | 19 | <1.0 | -- | 0.25 | 0.15 | <0.02 | 0.05 | <0.01 |

** = missing/censored data -- = no data

**Table B6.** Continued. 1998 DEP DWM Blackstone River Basin, instream physico-chemical data. All units in mg/L unless otherwise noted.

| | | | Time (24hr) | Alkalinity | Hardness | Specific Conductivity (umhos) | Chloride | Suspended Solids | Total Petroleum Hydrocarbons | Turbidity (NTU) | Total Kjeldahl Nitrogen | Ammonia | Nitrate | Total Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KETTLE BROOK** | | | | | | | | | | | | | | |
| Station: KB09, Mile Point: 5.5 | | | | | | | | | | | | | | |
| Description: upstream/west of Auburn Street, Leicester. | | | | | | | | | | | | | | |
| 51-0046 | | 07/08/98 | 9:38 | 13 | 20 | 130 | 24 | <1.0 | -- | 0.55 | 0.32 | <0.02 | 0.11 | 0.03 |
| **Unnamed and/or Undefined SARIS** | | | | | | | | | | | | | | |
| Station: KB02, Mile Point: 0.08 | | | | | | | | | | | | | | |
| Description: downstream from the outlet Leesville Pond, upstream of Oxford Street, Worcester. | | | | | | | | | | | | | | |
| 51-0026 | | 06/09/98 | 10:36 | 26 | 47 | -- | 55 | 1.8 | -- | 2.9 | ** | 0.02 | 0.14 | 0.04 |
| 51-0041 | 51-0042 | 07/08/98 | 10:41 | 23 | 35 | 210 | 42 | <1.0 | -- | 2.9 | 0.41 | <0.02 | 0.07 | 0.06 |
| 51-0042 | 51-0041 | 07/08/98 | 10:41 | 23 | 35 | 210 | 41 | <1.0 | -- | 2.9 | 0.39 | <0.02 | 0.06 | 0.06 |
| 51-0051 | | 08/04/98 | 11:00 | 33 | 50 | -- | 67 | 1.2 | -- | 2.3 | -- | <0.02 | 0.07 | 0.03 |
| **DARK BROOK** | | | | | | | | | | | | | | |
| Station: RB01, Mile Point: 1 | | | | | | | | | | | | | | |
| Description: downstream/north of Route 12, Auburn. | | | | | | | | | | | | | | |
| 51-0040 | | 07/08/98 | 11:11 | 20 | 35 | 210 | 42 | <1.0 | -- | 1.3 | 0.41 | 0.02 | 0.16 | 0.04 |
| 51-0052 | 51-0054 | 08/04/98 | 10:25 | 36 | 61 | -- | 82 | 1.0 | -- | 1.5 | -- | 0.03 | 0.28 | 0.03 |
| 51-0054 | 51-0052 | 08/04/98 | 10:25 | 36 | 61 | -- | 82 | 1.1 | -- | 1.4 | -- | 0.05 | 0.29 | 0.03 |
| **BEAVER BROOK** | | | | | | | | | | | | | | |
| Station: BB01, Mile Point: 0.1 | | | | | | | | | | | | | | |
| Description: upstream/northwest at Park Avenue, Worcester. | | | | | | | | | | | | | | |
| 51-0017 | | 05/12/98 | 10:31 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51-0024 | | 06/09/98 | 11:00 | 44 | 75 | -- | 61 | <1.0 | -- | 2.3 | ** | 0.23 | 1.1 | 0.08 |
| 51-0045 | | 07/08/98 | 8:55 | 48 | 73 | 350 | 57 | <1.0 | -- | 2.3 | 0.76 | 0.31 | 1.2 | 0.08 |
| 51-0055 | | 08/04/98 | 11:50 | 53 | 84 | -- | 62 | <1.0 | -- | 2.1 | -- | 0.39 | 1.4 | 0.06 |

** = missing/censored data -- = no data

**Table B7.** 1998 DEP DWM Blackstone River Basin bacteria data. Units in cfu/100 mLs.

| | | | Time (24hr) | FECAL | E-COLI | ENTEROCOCCUS |
|---|---|---|---|---|---|---|
| **BLACKSTONE RIVER** | | | | | | |
| Station: BLK01, Mile Point: 29.5 | | | | | | |
| Description: upstream/north at the southern most crossing of Millbury Street, Worcester. | | | | | | |
| 51-0028 | 51-0029 | 06/09/98 | 9:48 | 580 | -- | -- |
| 51-0029 | 51-0028 | 06/09/98 | 9:48 | 1,100 | -- | -- |
| 51-0038 | | 07/08/98 | 11:40 | 2,040 | -- | -- |
| 51-0056 | | 08/04/98 | 9:30 | 900 | -- | -- |
| **BLACKSTONE RIVER** | | | | | | |
| Station: BLK02, Mile Point: 27.6 | | | | | | |
| Description: upstream/northwest at McCracken Road, Millbury. | | | | | | |
| 51-0037 | | 07/08/98 | 1:40 | 840 | -- | -- |
| **BLACKSTONE RIVER** | | | | | | |
| Station: BLK07-A, Mile Point: 17.5 | | | | | | |
| Description: upstream/northwest at Sutton Street, Northbridge. | | | | | | |
| 51-0036 | | 07/08/98 | 12:13 | 1,020 | -- | -- |
| **BLACKSTONE RIVER** | | | | | | |
| Station: BLK12A, Mile Point: 3.4 | | | | | | |
| Description: upstream/west of Central Street, Millville. | | | | | | |
| 51-0035 | | 07/08/98 | 10:21 | 460 | -- | -- |
| **MILL RIVER** | | | | | | |
| Station: BLK15-1, Mile Point: 2.1 | | | | | | |
| Description: upstream/northwest of Summer Street (Park Street), Blackstone. | | | | | | |
| 51-0032 | 51-0033 | 07/08/98 | 10:57 | 100 | -- | -- |
| 51-0033 | 51-0032 | 07/08/98 | 10:57 | 80 | -- | -- |
| **WEST RIVER** | | | | | | |
| Station: WR12, Mile Point: 10 | | | | | | |
| Description: upstream/west of Glen Avenue, Upton. | | | | | | |
| 51-0074 | 51-0077 | 09/02/98 | 9:16 | 2,000 | -- | -- |
| 51-0077 | 51-0074 | 09/02/98 | 9:16 | 2,400 | -- | -- |
| **WEST RIVER** | | | | | | |
| Station: WR10, Mile Point: 8.6 | | | | | | |
| Description: downstream/south at Pleasant Street, Upton. | | | | | | |
| 51-0073 | | 09/02/98 | 10:00 | 82 | -- | -- |
| **WEST RIVER** | | | | | | |
| Station: WR03, Mile Point: 3.3 | | | | | | |
| Description: upstream/north, down the bank at East Hartford Street bridge, Uxbridge. | | | | | | |
| 51-0072 | | 09/02/98 | 11:40 | 16 | -- | -- |
| **CENTER BROOK** | | | | | | |
| Station: WR20, Mile Point: 1.6 | | | | | | |
| Description: upstream/northeast of Mendon Street, Upton. | | | | | | |
| 51-0075 | | 09/02/98 | 11:00 | 160 | -- | -- |
| **MUMFORD RIVER** | | | | | | |
| Station: BLK09-8, Mile Point: 11.3 | | | | | | |
| Description: upstream/north at Potter Road, Douglas. | | | | | | |
| 51-0031 | | 07/08/98 | 9:25 | <20 | -- | -- |
| **Unnamed and/or Undefined SARIS/Coes Pond** | | | | | | |
| Station: TB01, Mile Point: 0 | | | | | | |
| Description: upstream of outlet of Coes Pond, upstream/northwest of Park Avenue, Worcester. | | | | | | |
| 51-0025 | | 06/09/98 | 11:14 | 560 | -- | -- |
| 51-0044 | | 07/08/98 | 9:12 | 210 | -- | -- |
| 51-0050 | | 08/04/98 | 11:27 | 33 | -- | -- |

** = missing/censored data -- = no data

**Table B7.** Continued. 1998 DEP DWM Blackstone River Basin bacteria data. Units in cfu/100 mLs.

| | | | Time (24hr) | FECAL | E-COLI | ENTEROCOCCUS |
|---|---|---|---|---|---|---|
| **MIDDLE RIVER** | | | | | | |
| Station: BLK00, Mile Point: 0.1 | | | | | | |
| Description: upstream/west at the northern most crossing of Millbury Street, Worcester. | | | | | | |
| 51-0027 | | 06/09/98 | 10:12 | 2,400 | -- | -- |
| 51-0039 | | 07/08/98 | 11:58 | 1,820 | -- | -- |
| 51-0049 | | 08/04/98 | 9:00 | 920 | -- | -- |
| **KETTLE BROOK** | | | | | | |
| Station: KB10, Mile Point: 8 | | | | | | |
| Description: upstream/north of Earle Street, Leicester. | | | | | | |
| 51-0047 | | 07/08/98 | 10:01 | <20 | -- | -- |
| **KETTLE BROOK** | | | | | | |
| Station: KB09, Mile Point: 5.5 | | | | | | |
| Description: upstream/west of Auburn Street, Leicester. | | | | | | |
| 51-0046 | | 07/08/98 | 9:38 | 380 | -- | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | |
| Station: KB02, Mile Point: 0.08 | | | | | | |
| Description: downstream from the outlet Leesville Pond, upstream of Oxford Street, Worcester. | | | | | | |
| 51-0026 | | 06/09/98 | 10:36 | 880 | -- | -- |
| 51-0041 | 51-0042 | 07/08/98 | 10:41 | 40 | -- | -- |
| 51-0042 | 51-0041 | 07/08/98 | 10:41 | 20 | -- | -- |
| 51-0051 | | 08/04/98 | 11:00 | 620 | -- | -- |
| **DARK BROOK** | | | | | | |
| Station: RB01, Mile Point: 1 | | | | | | |
| Description: downstream/north of Route 12, Auburn. | | | | | | |
| 51-0040 | | 07/08/98 | 11:11 | 440 | -- | -- |
| 51-0052 | 51-0054 | 08/04/98 | 10:25 | 82 | -- | -- |
| 51-0054 | 51-0052 | 08/04/98 | 10:25 | 82 | -- | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | |
| Station: BB05, Mile Point: 0.7 | | | | | | |
| Description: upstream/north of Moreland Street, Worcester. (urban/intermittent stream, mile point is estimated from best fit line) | | | | | | |
| 51-0023 | | 05/12/98 | ** | ** | ** | ** |
| 51-0085 | | 09/30/98 | 12:05 | <16 | -- | -- |
| 51-0092 | | 10/27/98 | 11:31 | 18 | -- | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | |
| Station: BB04, Mile Point: 0.5 | | | | | | |
| Description: upstream/north of Assumption College driveway (upstream of small pond), Worcester. Driveway is unnamed road east of Salisbury Street. (urban/intermittent/culverted stream, mile point is estimated from best fit line) | | | | | | |
| 51-0020 | 51-0021 | 05/12/98 | 12:21 | ** | ** | ** |
| 51-0021 | 51-0020 | 05/12/98 | 12:21 | ** | ** | ** |
| 51-0082 | 51-0083 | 09/30/98 | 11:50 | 780 | -- | -- |
| 51-0083 | 51-0082 | 09/30/98 | 11:50 | 800 | -- | -- |
| 51-0089 | 51-0090 | 10/27/98 | 11:20 | 75 | -- | -- |
| 51-0090 | 51-0089 | 10/27/98 | 11:20 | 56 | -- | -- |
| **Unnamed and/or Undefined SARIS** | | | | | | |
| Station: BB03, Mile Point: 0.1 | | | | | | |
| Description: upstream/north of Flagg Street, Worcester. | | | | | | |
| 51-0019 | | 05/12/98 | 11:40 | ** | ** | ** |
| 51-0081 | | 09/30/98 | 11:35 | 16 | -- | -- |
| 51-0088 | | 10/27/98 | 11:11 | 6 | -- | -- |

** = missing/censored data -- = no data

**Table B7.** Continued. 1998 DEP DWM Blackstone River Basin bacteria data. Units in cfu/100 mLs.

| | | Time (24hr) | FECAL | E-COLI | ENTEROCOCCUS |
|---|---|---|---|---|---|
| **BEAVER BROOK** | | | | | |
| Station: BB02, Mile Point: 0.3 | | | | | |
| Description: downstream/south at Maywood Street, Worcester. | | | | | |
| 51-0018 | 05/12/98 | ** | ** | ** | ** |
| 51-0080 | 09/30/98 | 11:15 | 9,500 | -- | -- |
| 51-0087 | 10/27/98 | 10:45 | 6,400 | -- | -- |
| **BEAVER BROOK** | | | | | |
| Station: BB01, Mile Point: 0.1 | | | | | |
| Description: upstream/northwest at Park Avenue, Worcester. | | | | | |
| 51-0017 | 05/12/98 | 10:31 | ** | ** | ** |
| 51-0024 | 06/09/98 | 11:00 | 2,500 | -- | -- |
| 51-0045 | 07/08/98 | 8:55 | 880 | -- | -- |
| 51-0055 | 08/04/98 | 11:50 | 6,100 | -- | -- |
| 51-0079 | 09/30/98 | 10:40 | 8,700 | -- | -- |
| 51-0086 | 10/27/98 | 10:32 | 2,600 | -- | -- |

** = missing/censored data -- = no data

## MACROINVERTEBRATES

Results from DEP DWM 1998 benthic macroinvertebrate studies in the Blackstone River Basin are presented in Appendix C (Blackstone River Watershed 1998 Biological Assessment, author: John Fiorentino).

## FISH POPULATION

Results from the DEP DWM 1998 fish population survey in the Blackstone River Basin are presented in Appendix C (Blackstone River Watershed 1998 Biological Assessment, author: John Fiorentino).

## FISH TOXICS

Survey results (MA DEP 1998a) are presented in Table B8. The goal was to screen resident fishes for PCBs, organochlorine pesticides, and selected metals. Where possible, fish selected for analysis (Table B8) represented species and sizes desired by the angling public for consumption, as well as from different feeding guilds (i.e., predator, invertivore, omnivore).

As expected, a fairly depauperate fish community exists at University Park Pond. The water depth (average one meter), hypereutrophic conditions, and relatively small size (<2 acres) are all factors that contribute to a situation unfavorable for a healthy population of fish and worthy potential for sportsfishing/fish consumption. Composite samples of pumpkinseed sunfish (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), yellow bullheads (*Ameiurus natalis*) and an individual American eel (*Anguilla rostrata*) were collected from University Park Pond, Worcester and processed at the DWM laboratory. Brown bullheads (*Ameiurus nebulosus)*, white suckers (*C. commersoni*), white perch (*Morone americana*), yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*) were collected from Coes Reservoir in Worcester. All Coes Reservoir fish were processed as composite samples comprising three like sized individual fish. The samples from both ponds were analyzed for metals (As, Cd, Pb, Hg and Se), PCB, organochlorine pesticides and percent lipids. These data (MA DEP 1998a) are provided in Table B8.

**Table B8.** 1998 DEP DWM fish toxics monitoring data (mg/kg wet wt.) for Coes Reservoir and 'University Park Pond,' Worcester. Results (mg/kg wet wt.) are from composite samples of fillets with skin off unless otherwise noted.

| Sample ID | Collection Date | Species Code[1] | Length (cm) | Weight (gm) | Composite Sample ID (laboratory sample #) | Cd | Pb | Hg | As | Se | % Lipids | PCB (µg/g) | Pesticides (µg/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coes Reservoir, Worcester** | | | | | | | | | | | | | |
| COF98-01 | 7/8/98 | BB | 34.4 | 550 | | | | | | | | | |
| COF98-02 | 7/8/98 | BB | 34.0 | 490 | 98021 (L980444-1) | <0.02 | <0.20 | <0.010 | 0.208 | 0.196 | 0.22 | 0.29[3] | ND |
| COF98-03 | 7/8/98 | BB | 22.0 | 180 | | | | | | | | | |
| COF98-04 | 7/8/98 | WS | 45.1 | 1080 | 98022 | | | | | | | | |
| COF98-05 | 7/8/98 | WS | 44.6 | 990 | (L980444-2) | <0.02 | <0.20 | 0.100 | 0.077 | 0.265 | 0.75 | 0.19[3] | ND |
| COF98-06 | 7/8/98 | WS | 45.6 | 1040 | duplicate | <0.02 | <0.02 | -- | 0.075 | 0.283 | | | |
| COF98-07 | 7/8/98 | WP | 23.2 | 200 | | | | | | | | | |
| COF98-08 | 7/8/98 | WP | 23.7 | 200 | 98023 (L980444-3) | <0.02 | <0.20 | 0.400 | <0.040 | 0.473 | 0.74 | 0.18[3] | 0.016[4] |
| COF98-09 | 7/8/98 | WP | 21.9 | 170 | | | | | | | | | |
| COF98-10 | 7/8/98 | YP | 29.4 | 290 | | | | | | | | | |
| COF98-11 | 7/8/98 | YP | 28.4 | 250 | 98024 (L980444-4) | <0.02 | <0.20 | 0.190 | 0.040 | 0.192 | 0.11 | ND | ND |
| COF98-12 | 7/8/98 | YP | 27.8 | 250 | | | | | | | | | |
| COF98-13 | 7/8/98 | LMB | 38.4 | 820 | | | | | | | | | |
| COF98-14 | 7/8/98 | LMB | 35.5 | 720 | 98025 (L980444-5) | <0.02 | <0.20 | 0.280 | <0.040 | 0.195 | 0.06 | ND | ND |
| COF98-15 | 7/8/98 | LMB | 34.0 | 560 | | | | | | | | | |
| COF98-16 | 7/8/98 | BC | 25.3 | 210 | 98026 | | | | | | | | |
| COF98-17 | 7/8/98 | BC | 23.7 | 210 | (L980444-6) | <0.02 | <0.20 | 0.064 | 0.049 | 0.236 | 0.06 | ND | ND |
| COF98-18 | 7/8/98 | BC | 21.8 | 170 | duplicate | | | 0.074 | | | | | |
| **'University Park Pond' ,Worcester** (unnamed pond east of Crystal Street, Worcester : locally known as University Park Pond) | | | | | | | | | | | | | |
| UPF98-01 | 7/2/98 | YB | 29.4 | 350 | | | | | | | | | |
| UPF98-02 | 7/2/98 | YB | 31.5 | 520 | 98017 (L980445-1) | <0.02 | <0.20 | .0.10 | <0.040 | 0.326 | 0.17 | ND | 0.021[4] |
| UPF98-03 | 7/2/98 | YB | 30.7 | 420 | | | | | | | | | |
| UPF98-04 | 7/2/98 | BC | 25.6 | 300 | 98018 | | | | | | | | |
| UPF98-05 | 7/2/98 | BC | 17.9 | 100 | (L980445-2) | <0.02 | <0.20 | 0.14 | <0.040 | 0.472 | 0.23 | ND | 0.020[4] |
| UPF98-06 | 7/2/98 | P | 15.8 | 100 | | | | | | | | | |
| UPF98-07 | 7/2/98 | P | 14.6 | 80 | | | | | | | | | |
| UPF98-08 | 7/2/98 | P | 13.7 | 50 | 98019 (L980445-3) | <0.02 | <0.20 | 0.04 | <0.040 | 0.503 | 0.54 | ND | 0.015[4] |
| UPF98-09 | 7/2/98 | P | 12.5 | 40 | | | | | | | | | |
| UPF98-10 | 7/2/98 | P | 12.7 | 40 | | | | | | | | | |
| UPF98-11 | 7/2/98 | AE | 71.5 | 780 | 98020[2] (L980445-4) | <0.02 | <0.20 | 0.088 | <0.040 | 0.451 | 8.4 | ND | 0.27[4] 0.097[5] 0.035[6] |

[1]Species American eel (AE) *Anguilla rostrata*
brown bullhead (BB) *Ameiurus nebulosus*
black crappie (BC) *Pomoxis nigromaculatus*
largemouth bass (LMB) *Micropterus salmoides*
pumpkinseed (P) *Lepomis gibbosus*
white perch (WP) *Morone americana*
white sucker (WS) *Castomus commersoni*
yellow bullhead (YB) *Ameiurus natalis*
yellow perch (YP) *Perca flavescens*

[2] Individual fish not composite sample.
[3]Arochlor 1260
[4]DDE
[5]DDD
[6]DDT

ND - not detected or the analytical result is at or below the established detection limit (MDL). See Appendix A for MDL.

Cadmium and lead were not detected in the edible fillets of any sample analyzed from this survey. Arsenic was not detected in any of the University Park Pond samples however it was above the 0.04 mg/kg wet weight detection limit in four of the six samples from Coes Reservoir ( 0.040 mg/kg to 0.208 mg/kg wet weight). Selenium was detected in all samples analyzed ranging from 0.192 to 0.503 mg/kg wet weight. Mercury in the fish tissue from University Park Pond ranged between 0.088 and 0.14 mg/kg wet weight and from <0.010 to 0.40 mg/kg wet weight from the Coes Reservoir fish samples.

PCBs were below detection in all samples analyzed from University Park Pond, however three of the six Coes Reservoir samples contained detectable levels of PCBs that ranged from 0.018 to 0.029 mg/kg wet weight. Organochlorine pesticides were present in all of the University Park Pond fish. The eel fillet had, detectable levels of DDE, DDD, and DDT (0.27, 0.097, and 0.035 mg/kg wet weight respectively). The remaining three fish samples each contained measurable levels of DDE that were between 0.015 and

0.021 mg/kg wet weight. The % lipids content of the fish analyzed ranged between 0.06 % in the bass and crappie tissue, and 8.4% in the eel.

According to standard practice, all laboratory analytical results were forwarded to the Department of Public Health (DPH) for review. The data presented did not trigger any site-specific advisory against the consumption of fish from either pond, however DPH's statewide fish consumption advisory should be considered. The current advisory due to the ubiquitous, elevated levels of mercury in some Massachusetts freshwater fish, recommends that women should refrain from eating freshwater fish while pregnant.

## LAKES

Lake synoptic survey results (MA DEP 1998b) are presented in Table B9.

**TABLE B9.** 1998 DEP DWM Blackstone River Basin Survey. Blackstone watershed lake status during summer 1997. NOTE: All waters are Class B.

| LAKE | WBID | SIZE (Acres) | TROPHIC STATE | OBSERVATIONS, Objectionable Conditions |
|---|---|---|---|---|
| Caprons Pond, Uxbridge | MA51014 | 15 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, developed, commercial and residential, around pond, non-native plants (Cc, M. sp.), ~50% of the surface at Heritage Park is covered by submergent, floating, and emergent plants |
| Carpenter Reservoir, Northbridge (Carpenter Pond) | MA51015 | 86 | E | Moderate turbidity, moderate dissolved organics, moderate blue-green algal bloom, development on east side of southern basin, <5% of entire reservoir surface covered by dense aquatic plants, ≤25% loss of open water over the entire reservoir |
| Clark Reservoir, Sutton (Clark Pond) | MA51022 | 32 | E | "encroaching emergent and floating leaved plants, 75-100% around most of pond shore (~1/3 area) then patches of floating leaved in open water, no development other than 1 new street where pond accessed" from 1994 notes (MA DEP 1994) |
| Coes Reservoir, Worcester | MA51024 | 90 | E | Moderate turbidity, slight dissolved organics, moderate algal bloom (blue green bloom in clumps), dirty foam on beach, ~20 ducks and 100 seagulls, non-native plants (Ls, Ms), <5% of entire surface covered with dense submergent, emergent and floating plants, patches of dense plants in northeast bay and around point, , ≤25% loss of open water over the entire reservoir |
| Cook Pond, Worcester | MA51027 | 20 | E | Moderate turbidity, moderate dissolved organics, slight algal bloom, rebuilding outlet dam structure for bottom release, pond drawn down 3-5 feet and 15 feet from shore on east side, non-native plants (Cc), 90% of entire surface of pond covered with submergent and floating plants, ~ 4 acres of open water left in 2 pools |
| Dark Brook Reservoir, Auburn {south basin} (Partridge Pond) | MA51035 | 57 | E | Moderate grey turbidity, moderate dissolved organics, slight algal bloom, non-native plants (Ls, Ms, Nm), 50% of surface covered with submergent plants, ≤25% loss of open water over the entire reservoir |

**WBID** – Waterbody Identification code.
**Trophic State:** **E**= Eutrophic, **H**= Hypereutrophic, **M**= Mesotrophic, **U**= Undetermined.
**Non-native Plants:** **Cc** = *Cabomba caroliniana*, **Ls** = *Lythrum salicaria*, **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum*, **Nm**= *Najas minor*, **Pa** = *Phragmites australis*
**Note:** **M. sp.** – Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.
* trophic status based on 1994 survey

**TABLE B9.** Continued. 1998 DEP DWM Blackstone River Basin Survey. Blackstone watershed lake status during summer 1997. NOTE: All waters are Class B.

| LAKE | WBID | SIZE (Acres) | TROPHIC STATE | OBSERVATIONS, Objectionable Conditions |
|---|---|---|---|---|
| Dark Brook Reservoir, Auburn {north basin} | MA51036 | 256 | E | Slight turbidity, slight dissolved organics, slight algal bloom, moderate development, non-native plants (Ls, Ms), dense submergent, floating, and emergent plants present over <5% of surface, , ≤25% loss of open water over the entire reservoir |
| Eddy Pond, Auburn | MA51043 | 134 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, some development on northwest end, Route 395 along whole west side, heavy foam, non-native plants (M. sp.) 100% of surface covered by submergent and floating plants from state boat ramp to Cedar St. |
| Flint Pond, Worcester/Shrewsbury/Grafton {north basin} | MA51050 | 84 | E | Slight turbidity, slight dissolved organics, slight algal bloom, considerable development around pond, non-native plants (Ls, Cc, Ms) <5% of surface covered with dense floating and emergent plants |
| Flint Pond, Worcester/Shrewsbury {south basin} | MA51188 | 170 | E | Slight turbidity, slight dissolved organics, slight algal bloom, extensive development on north, west, and southeast shores, non-native plants (Ls, Cc, Mh, Ms), dense submergent and floating plants |
| Harrington Pool, Uxbridge (West Hill Dam Impoundment) | MA51197 | 1.0 | U | Slight turbidity, moderate dissolved organics, slight algal bloom, non-native plants (Ls), <5% of entire lake covered with dense aquatic plants, some patches of dense floating/submergents to south of roped (swimming) area, ≤25% loss of open water habitat over entire pond |
| Harris Pond, Blackstone | MA51058 | 93 | E | Moderate turbidity, moderate dissolved organics, moderate blue-green algal bloom, oil sheen, powdery brown scum on windward shore, non-native plants (Cc), <5% of entire surface covered with dense aquatic plants, , ≤25% loss of open water over the entire pond |
| Hopedale Pond, Hopedale | MA51065 | 95 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, heavily developed on southern end, north undeveloped, beach on east side, non-native plants (Ls, Cc, Mh), 75% of the surface of the west side of the pond is covered with dense submegent, floating, and emergent plants |
| Ironstone Reservoir, Uxbridge | MA51074 | 26 | E | Slight turbidity, slight dissolved organics, slight algal bloom, one house and "beach" on west side, gravel pit further back on west side, little other development, non-native plants (Cc, M. sp.), dense floating, submergent, and emergent plants covering most of the surface of the reservoir, 100% of the surface along the east shore covered with very dense floating, submergent and emergent plants |

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**Non-native Plants:** **Cc** = *Cabomba caroliniana*, **Ls** = *Lythrum salicaria*, **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum*, **Nm**= *Najas minor*, **Pa** = *Phragmites australis*
**Note:** **M. sp.** – Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.
* trophic status based on 1994 survey

**TABLE B9.** Continued. 1998 DEP DWM Blackstone River Basin Survey. Blackstone watershed lake status during summer 1997. NOTE: All waters are Class B.

| LAKE | WBID | SIZE (Acres) | TROPHIC STATE | OBSERVATIONS, Objectionable Conditions |
|---|---|---|---|---|
| Jenks Reservoir, Bellingham | MA51075 | 27 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, development around east basin and on east side of west basin, slight odor at spillway, non-native plants (Pa, M. sp.), 100% of surface of east basin covered with dense to very dense emergent, floating, and submergent plants, west basin <5% of surface covered with dense aquatic plants |
| Lackey Pond, Sutton/Uxbridge | MA51083 | 117 | E | Moderate turbidity, moderate dissolved organics, moderate algal bloom, dead fish smell, trash, water column "brownish", dam in disrepair, little water being held, mostly a channel remaining, non-native plants (Ls, Pa) <10% of entire surface covered with dense emergent, floating, and submergent plants |
| Linwood Pond, Northbridge | MA51088 | 61 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, great blue heron, non-native plants (Ls, Cc), submergents very dense along shorelines |
| Manchaug Pond, Douglas/Sutton | MA51091 | 348 | M* | Slight to moderate turbidity, slight dissolved organics, moderate algal bloom, development moderate to heavy around most of lake, non-native plants (Cc, M. sp.), <5% of entire surface covered by submergent and emergent plants, ≤25% loss of open water habitat over entire pond |
| Meadow Pond, Northbridge/Sutton (Whitinsville) | MA51193 | 45 | E | Slight to moderate turbidity, moderate dissolved organics, slight algal bloom, industrial development on north shore, oil sheen on surface, odor of solvent/organic, non-native plants (Ls, Cc), dense patches of floating and emergents in southwest arm |
| Newton Pond, Shrewsbury/Boylston (Mud Pond) | MA51110 | 48 | E | Slight to moderate turbidity, slight dissolved organics, slight algal bloom, 30 geese, moderate development on east shore, non-native plants (Cc, Mh), 75% of surface with very dense floating and submergent plants in northern end of pond, ≤25% loss of open water habitat over entire pond |
| Patch Reservoir, Worcester | MA51118 | 31 | E | Moderate grey/brown turbidity, moderate dissolved organics, moderate algal bloom (slight blue-green bloom at surface), trash, development on north, northwest, and western shores, non-native plants (Ls), <5% of entire surface covered with floating and emergent plants, ≤25% loss of open water habitat over entire reservoir |
| Pratt Pond, Upton | MA51123 | 38 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, moderate development, cemetery, non-native plants (M. sp.), 100% of surface covered with floating submergent, and emergent plants in small cove adjacent to athletic fields and town beach, ≤25% loss of open water habitat over entire pond |

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**Non-native Plants:** **Cc** = *Cabomba caroliniana*, **Ls** = *Lythrum salicaria*, **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum*, **Nm**= *Najas minor*, **Pa** = *Phragmites australis*
**Note:** **M. sp.** – Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.
* trophic status based on 1994 survey

**TABLE B9.** Continued. 1998 DEP DWM Blackstone River Basin Survey. Blackstone watershed lake status during summer 1997. NOTE: All waters are Class B.

| LAKE | WBID | SIZE (Acres) | TROPHIC STATE | OBSERVATIONS, Objectionable Conditions |
|---|---|---|---|---|
| Lake Ripple, Grafton | MA51135 | 63 | H | Slight turbidity, slight dissolved organics, slight algal bloom, developed except for west/northwest side, unpleasant somewhat septic odor, non-native plants (Ls, Cc, M. sp.), west side of pond 75% covered with submergents, northeast corner of east cove 50% covered with submergents |
| Salisbury Pond, Worcester | MA51142 | 18 | E | Moderate to excessive turbidity, slight dissolved organics, moderate algal bloom, storm drain flowing into pond, 20 ducks, shopping cart, tires, oil sheen, fuel oil smell, duckweed, non-native plants (Ls), <5% of entire surface covered with emergent plants, ≤25% loss of open water habitat over entire pond |
| Silver Lake, Bellingham (Hoag lake) | MA51150 | 70 | U | Water quality not available (viewed from distance), heavily developed on both sides of pond, aquatic plant cover on west side of pond |
| Silver Lake, Grafton (Kiddville Pond, Kittville Pond) | MA51151 | 23 | E | Slight turbidity, dark dissolved organics, slight algal bloom, water level down 5 feet, dam leaking, extensive mud flat (100 feet on Rt. 140 (west) side of lake), little development, non-native plants (M. sp.), <5% of entire surface covered with aquatic plants |
| Singletary Pond, Millbury/Sutton (Singletary Lake) | MA51152 | 330 | U | Moderate turbidity, moderate dissolved organics, moderate algal bloom, heavy development on all but east side, non-native plants (Ls, Ms), <5% of entire surface covered with dense aquatic plants, ≤25% loss of open water habitat over entire pond |
| Smiths Pond, Leicester (Cherry Valley Pond) | MA51156 | 20 | H | Excessive turbidity, slight dissolved organics, dense algal bloom, some urban development around 50% of pond, vegetation around rest, green and brown scum, non-native plants (Ls), dense beds in a few spots in south/southwest portion of pond, ≤25% loss of open water habitat over entire pond |
| Stoneville Pond, Auburn {lower reservoir} | MA51160 | 43 | H | Slight turbidity, slight dissolved organics, moderate algal bloom (mats), non-native plants (Ls, Cc), north end of pond beyond restrictions covered with dense to very dense aquatic plants, entire southwest arm past restrictions covered with dense aquatic plants |
| Stoneville Reservoir, Auburn {upper reservoir} | MA51161 | 61 | U | Moderate turbidity, slight dissolved organics, slight algal bloom, fairly developed around entire pond except northeast, <5% of entire surface covered with dense aquatic plants, ≤25% loss of open water habitat over entire reservoir |
| Tinker Hill Pond, Auburn | MA51167 | 37 | E | Slight turbidity, moderate dissolved organics, slight algal bloom, non-native plants (Ls, Nm, M. sp.), 100% of surface dense with submergent, floating, and emergent vegetation |

**WBID** – Waterbody Identification code.
**Trophic State**: **E**= Eutrophic, **H**= Hypereutrophic, **M**= Mesotrophic, **U**= Undetermined.
**Non-native Plants:** **Cc** = *Cabomba caroliniana*, **Ls** = *Lythrum salicaria*, **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum*, **Nm**= *Najas minor*, **Pa** = *Phragmites australis*
**Note: M. sp.** – Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.
* trophic status based on 1994 survey

**TABLE B9.** Continued. 1998 DEP DWM Blackstone River Basin Survey. Blackstone watershed lake status during summer 1997. NOTE: All waters are Class B.

| LAKE | WBID | SIZE (Acres) | TROPHIC STATE | OBSERVATIONS, Objectionable Conditions |
|---|---|---|---|---|
| Tuckers Pond, Sutton | MA51169 | 28 | U | Slight to moderate turbidity, moderate dissolved organics, slight to moderate algal bloom, some development on south, west, and north side, non-native plants (Mh), northwest cove of pond very densely covered with aquatic plants, remainder of pond, "open water " at surface |
| Waite Pond, Leicester | MA51170 | 54 | U | Slight turbidity, slight dissolved organics, slight algal bloom, development around whole pond, oily scum, non-native plants (Ls, M. sp.), extreme southern end of southwest cove and small cove on west side covered with dense aquatic vegetation, ≤25% loss of open water habitat over entire pond |
| West River Pond, Uxbridge | MA51177 | 37 | E | Moderate turbidity, moderate dissolved organics, duckweed, some new houses about midway up west shore, otherwise little development, non-native plants (Cc), ~75% of surface covered with floating, emergent, and submergent plants |
| Whitin Pond, North Uxbridge | MA51178 | 23 | E | Viewed from road, no water quality available, developed around pond, non-native plants (Cc), all but east central part of pond covered with dense floating or submergent vegetation |
| Whitins Pond, Northbridge/Sutton | MA51180 | 167 | M | Slight to moderate turbidity, slight to moderate dissolved organics, slight to moderate algal bloom, water column "greenish", blue green scum in cove, non-native plants (Ls, Cc, M. sp.), south basin is 80% covered with submergents and emergents, northwest side is 90% covered with submegent and emergent plants |
| Wildwood Lake, Upton/Grafton | MA51181 | 38 | E | Slight turbidity, moderate dissolved organics, slight algal bloom (mats), appears to be treated with SONAR (Signs posted—treating for nuisance plants), non-native plants (Ls, Cc, M. sp.), upper arm of pond is 100% covered with very dense submergent plants, near Williams Street 50% covered with dense aquatic plants |

**WBID** – Waterbody Identification code.
**Trophic State**: **E**= Eutrophic, **H**= Hypereutrophic, **M**= Mesotrophic, **U**= Undetermined.
**Non-native Plants:** **Cc** = *Cabomba caroliniana*, **Ls** = *Lythrum salicaria*, **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum*, **Nm**= *Najas minor*, **Pa** = *Phragmites australis*
**Note:** **M. sp.** – Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.
* trophic status based on 1994 survey

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# APPENDIX C – 1998 DEP DWM BIOMONITORING TECHNICAL MEMORANDUM

**Subject:** **BLACKSTONE RIVER WATERSHED 1998 BIOLOGICAL ASSESSMENT**

Prepared by: John Fiorentino, DEP/ Division of Watershed Management, Worcester, MA

Date: 28 February 2000

## INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Plafkin et al. 1989, Barbour et al. 1995). Biological surveys and assessments are the primary approaches to biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MADEP/DWM) 1998 Blackstone River watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of various portions of the watershed. A total of 13 biomonitoring stations were sampled to investigate the effects of various point source and nonpoint source stressors—both historical and current—on the aquatic communities of the Blackstone River watershed. Some stream segments were previously "unassessed" by DEP, while historical DEP biomonitoring stations—sampled in 1977, 1985, and most recently in 1991—were reevaluated to determine if water quality and habitat conditions have improved or worsened over time. In some cases (i.e., point source investigations), a site-specific sampling approach was implemented, in which the aquatic community and habitat downstream from the perceived stressor (downstream study site) were compared to an upstream reference station (control site) representative of "least disturbed" biological conditions in the waterbody. While the alternative to this site-specific approach is to compare the study site to a regional reference station (i.e., "best attainable" condition), the site-specific approach is more appropriate for an assessment of a known or suspected stressor, provided that the stations being compared share basically similar instream and riparian habitat characteristics (Plafkin et al. 1989). Since both the quality and quantity of available habitat affect the structure and composition of resident biological communities, effects of such features can be minimized by sampling similar habitats at stations being compared, providing a more direct comparison of water quality conditions (Plafkin et al. 1989). Sampling highly similar habitats will also reduce metric variability, attributable to factors such as current speed and substrate type.

To provide additional information necessary for making basin-wide aquatic life use designations required by Section 305b of the Clean Water Act, all Blackstone River watershed stations were compared to a regional reference station as well. Use of a regional reference station is particularly useful in assessing nonpoint source (NPS) pollution impacts (e.g., physical habitat degradation) at upstream control sites as well as downstream sites suspected as chemically-impacted from known point source stressors (Hughes 1989). Regional reference stations were established in the Mumford River (third-order) and Kettle Brook (first-order). Both stations were situated upstream from all known point sources of water pollution, and they were also assumed to be relatively unimpacted by nonpoint sources. The decision of which reference station to use for comparisons to a study site was based on comparability of stream morphology, flow regimes, and drainage area. Sampling locations, along with station identification numbers and dates, are noted in Table 1. Sampling locations are also shown in Figure 1.

**Table 1.** List of macroinvertebrate biomonitoring station locations sampled during the 1998 Blackstone River watershed survey, including station identification number, station description, and sampling date.

| Station | Site Description | Sampling Date |
|---|---|---|
| BLK00A | Middle River, downstream from Riley Research footbridge, Worcester, MA | 14 July 1998 |
| BLK01 | Blackstone River, downstream from Millbury St., Worcester, MA | 14 July 1998 |
| BLK02 | Blackstone River, downstream from McCracken Rd., Millbury, MA | 14 July 1998 |
| BLK07 | Blackstone River, upstream from Sutton St., Northbridge, MA | 15 July 1998 |
| BLK12A | Blackstone River, upstream from Central St., Millville, MA | 15 July 1998 |
| KB10 | Kettle Brook, downstream from Earle St., Leicester, MA | 9 July 1998 |
| KB09 | Kettle Brook, downstream from Auburn St., Leicester, MA | 9 July 1998 |
| KB02 | Kettle Brook, downstream from Oxford St., Worcester, MA | 16 July 1998 |
| TB02 | Tatnuck Brook, upstream from Williams Millpond, Worcester, MA | 9 July 1998 |
| RB01 | Dark Brook, downstream from Route 12, Auburn, MA | 10 July 1998 |
| BLK09-8A | Mumford River, downstream from Manchaug St., Douglas, MA | 15 July 1998 |
| WR01 | West River, upstream from West River St., Upton, MA | 15 July 1998 |
| BLK15-1 | Mill River, downstream from Park St., Blackstone, MA | 10 July 1998 |


**Figure 1.** Location of DWM biomonitoring stations for the 1998 Blackstone River watershed survey.

Benthic macroinvertebrate biomonitoring was conducted from 9 July to 16 July 1998 by John Fiorentino and Robert Nuzzo of DEP/DWM, with assistance from Mary Crain Penniman of DEP-CERO. A brief description of the 1998 biomonitoring survey stations—including the rationale behind sampling efforts and pertinent background information—is as follows:

The main objectives of biomonitoring in the Blackstone River watershed were: (a) to determine the biological health of streams within the watershed by conducting assessments based on aquatic macroinvertebrate communities; and (b) to identify problem stream segments so that efforts can be focussed on developing NPDES permits, stormwater management, and control of other nonpoint source (NPS) pollution. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling at locations throughout the Blackstone River watershed.

2. Based upon the macroinvertebrate data, identify river segments within the watershed with potential point/nonpoint source pollution problems; and

3. Using the benthic macroinvertebrate data and supporting water chemistry and field data, assess the types of water quality problems that are present, and if possible, make recommendations for remedial actions. Provide macroinvertebrate data to DWM's Environmental Monitoring and Assessment Program to be used in making aquatic life use assessments required by Section 305b of the Clean Water Act.

Benthic macroinvertebrate biomonitoring was conducted from 9 July to 16 July 1998 by John Fiorentino and Robert Nuzzo of DEP/DWM, with assistance from Mary Crain Penniman of DEP-CERO. A brief description of the 1998 biomonitoring survey stations—including the rationale behind sampling efforts and pertinent background information—is as follows:

*BLK00A*—Middle River, downstream from Interstate 290 and Riley Research Inc., Worcester. Biomonitoring data for this station exists from 1977 and 1985 DEP surveys. This site also served as an upstream control in the bracketing of the City of Worcester's Combined Sewer Overflow Treatment Facility (NPDES Permit # MA012997), which discharges to Mill Brook just downstream. This facility is engaged in treatment of combined sewer overflow from the Upper Blackstone Water Pollution Abatement District (UBWPAD).

*BLK01*—Blackstone River, downstream from Millbury St., Worcester. A newly established DEP biomonitoring station, sampling was conducted here to assess the impacts from the Worcester CSO located just upstream. Mill Brook has historically contributed to significant organic pollutant loadings, as well as likely toxic effects—possibly originating from New England Plating, Inc.—on downstream biota (Johnson et al. 1992; Szal 1992). This station also served as the upstream control in the bracketing of the UPWPAD wastewater treatment facility (NPDES Permit # MA0102369) discharge which is just downstream.

*BLK02*—Blackstone River, downstream from McCracken Rd., Millbury. There are considerable historical DEP benthos data (1973, 1977, 1985, 1991) indicating a degraded aquatic community at this station (MWRC 1974; Johnson et al. 1992; Szal 1992). Sampling was conducted here to assess the impact of the largest point source discharger in the watershed—the UBWPAD. Toxic effects of chlorine and/or heavy metals contamination—suspected to originate from the UBWPAD discharge or other more upstream sources such as the Worcester CSO—were documented by DEP during 1985 and 1991 biosurveys at this station (Johnson et al. 1992; Szal 1992). It was anticipated that recent improvements to the UBWPAD effluent quality from chlorination/dechlorination and nitrification treatment would result in continued improvements to biological integrity downstream.

*BLK07*—Blackstone River, upstream from Sutton St., Northbridge. This is another mainstem station historically sampled by DEP (1977, 1985, 1991) in which significant impacts to the benthic community were found (Johnson et al. 1992; Szal 1992). There are two wastewater treatment facilities between here and BLK02—Millbury WWTP (NPDES Permit # MA0100650) and Grafton WWTP (NPDES Permit # MA0101311).

*BLK12A*—Blackstone River, upstream from Central St., Millville. Historical data (1973, 1977, 1985, 1991) suggest gradual recovery to the aquatic community here, although there are two municipal treatment facilities that discharge to the mainstem upstream—Uxbridge WWTP (NPDES Permit # MA0102440) and Northbridge WWTP (NPDES Permit # MA0100722). This was the final mainstem station sampled before the Blackstone River enters Rhode Island.

*KB10*—Kettle Brook, downstream from Earle St., Leicester. DEP last conducted macroinvertebrate sampling here in 1977. This station was chosen as a reference station for all tributaries sampled in the watershed. This segment is located between Kettle Brook Reservoirs #1 and #2, and has been found to be of excellent water quality and habitat quality. This portion of Kettle Brook has been designated a Class A Outstanding Resource Water (ORW) (MADEP and USEPA 1995).

*KB09*—Kettle Brook, downstream from Auburn St., Leicester. This station was sampled by DEP in 1977. The severe degradation of the benthic community and possible presence of toxicants were attributed to its location downstream from the treated process and sanitary wastewater discharge (NPDES Permit # MA0004171) of Worcester Spinning and Finishing, Inc. (Johnson et al. 1992). The company has since closed operations, and it is anticipated that the excellent habitat in this stream segment may now support a healthy and diverse aquatic assemblage.

*KB02*—Kettle Brook, downstream from Oxford St. (below Leesville Pond), Worcester. Historically (1973, 1977, 1985), this has been the most downstream station on Kettle Brook sampled by DEP before its confluence with the Middle River. Biomonitoring was conducted here to assess biological conditions in the stream and to determine if conditions have improved or worsened over time. There are numerous potential nonpoint source stressors upstream, as this portion of the sub-basin is highly urbanized. Historically, this station has shown signs of moderate organic enrichment (Johnson et al. 1992).

*TB02*—Tatnuck Brook, upstream from Williams Millpond, Worcester. Although this is one of the major headwater streams that form the Middle River, and ultimately the Blackstone River, there are no historical biological data from it. This was the farthest downstream station in Tatnuck Brook where macroinvertebrate biomonitoring was logistically feasible. Sampling here provides DEP with much needed 305b assessment information and addresses some of the obvious nonpoint source issues in the sub-basin, particularly those associated with heavy residential and commercial land use.

*RB01*—Dark Brook, downstream from Route 12, Auburn. This is another previously "unassessed" stream despite significant flow contributions to the Blackstone River. Sampling was conducted here to provide DEP with baseline biomonitoring data, as well as to assess nonpoint source pollution impacts—if any—from the Auburn Mall located immediately upstream.

*BLK09-8A*—Mumford River, downstream from Manchaug St., Douglas. This station is located just downstream from a historical DEP sampling station (1973, 1977, 1985, 1991). The station was moved downstream to a site offering better habitat, as BLK09-8A serves as a biomonitoring reference station for the Blackstone River and Middle River stations. Thus, it will provide DEP with new benthos data, as well as aid in the assessment of the mainstem stations. As a reference station, it is considered to represent the "best attainable" (i.e., "least impacted") conditions in the watershed in terms of habitat and water quality.

*WR01*—West River, upstream from West River St., Upton. Although DEP conducted macroinvertebrate sampling at several stations in this stream in 1973, this is a newly created station, and the only location appropriate for current biomonitoring protocols. Sampling here will provide assessment data for DEP, and will address the primary stressor in the sub-basin—the Upton WWTP (NPDES Permit # MA0100196), which is located approximately one mile upstream. The West River is annually stocked with trout by the Massachusetts Division of Fisheries, Wildlife and Environmental Law Enforcement (MADFWELE).

*BLK15-1*—Mill River, downstream from Park St., Blackstone. Biomonitoring was conducted here in 1977, 1985, and 1991. It is the farthest downstream station where macroinvertebrates can effectively be sampled before the Mill River joins the Blackstone River in Woonsocket, Rhode Island. The Hopedale WWTP (NPDES Permit # MA0102202) is the major anthropogenic perturbation upstream, although numerous sand and gravel operations exist throughout the sub-basin as well. Mill River is annually stocked with trout by MADFWELE.

# METHODS

## *MACROINVERTEBRATE SAMPLING AND HABITAT ASSESSMENTS*

Macroinvertebrate sampling and processing procedures are described in detail in the benthos monitoring SOP (Nuzzo 1999) but a brief description will be given here. Sampling was conducted throughout a 100 m reach, in riffle/run areas with fast currents and cobble/gravel substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 $m^2$. Samples were preserved in the field with denatured 95% ethanol, then brought to the DWM lab for processing. Before leaving the sample reach, habitat qualities were scored using a modification of the evaluation procedure in Plafkin et al. (1989). The habitat assessment is intended to support the biosurvey and enhance the interpretation of the biological data. The matrix used to assess habitat quality is based on key physical characteristics of the water body and surrounding land use. Most parameters evaluated are instream physical attributes often related to overall land use and are potential sources of limitation to the aquatic biota (Plafkin et al. 1989). The ten habitat parameters are as follows: instream cover, epifaunal substrate, embeddedness, sediment deposition, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to a regional reference station and/or a site-specific control (upstream reference) station to provide a final habitat ranking.

Macroinvertebrate sample processing entailed distributing a sample in pans, selecting grids within the pans at random, and sorting specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). Based on the taxonomy various community, population, and functional parameters, or "metrics," were calculated which allow an investigator to measure important aspects of the biological integrity of the community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated. Deficiency of any one metric should not invalidate the entire approach (Plafkin et al. 1989). Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for a selected unimpaired reference station (i.e., "best attainable" situation) yields an impairment score for each site. RBP III analysis separates sites into four categories: non-impaired, slightly impaired, moderately impaired, and severely impaired. Impairment of the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989). Those biological metrics calculated and used in the analysis of Blackstone River watershed macroinvertebrate data are listed and defined below. For a more detailed description of metrics used to evaluate benthos data see Plafkin et al. (1989):

1. Taxa richness—a measure based on the number of taxa present. The lowest possible taxonomic level is assumed to be genus or species.

2. EPT Index—a count of the number of genera/species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). As a group these are considered three of the more sensitive aquatic insect orders. Therefore, the greater the contribution to total richness from these three orders, the healthier the community.

3. Biotic Index—based on the Hilsenhoff Biotic Index (HBI), this is an index designed to produce a numerical value to indicate the level of organic pollution. Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. A value of zero indicates the taxon is highly intolerant of pollution and is likely to be found only in pollution-free waters. A value of ten indicates the taxon is tolerant of pollution and may be found in highly polluted waters. The number of organisms and the individually assigned values are used in a mathematical formula that describes the degree of organic pollution at the study site. The formula for calculating HBI is:

$$HBI = \sum \frac{x_i t_i}{n}$$

where $x_i$ = number of individuals within a taxon
$t_i$ = tolerance value of a taxon
n = total number of organisms in the sample

4. Ratio of EPT and Chironomidae Abundance—The EPT and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations having a disproportionate number of the generally tolerant Chironomidae ("midges") relative to the more sensitive insect groups may indicate environmental stress.

5. Percent Contribution Dominant Taxon—is the percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress. Conversely, more balance among species indicates a healthier community.

6. Ratio of Scraper and Filtering Collector Functional Feeding Groups—this ratio reflects the community food base. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source (Plafkin et al. 1989). Scrapers predominate when diatoms are the dominant food resource, and decrease in adundance when filamentous algae and mosses prevail. Filtering collectors thrive where filamentous algae and mosses are prevalent and where fine particulate organic matter (FPOM) levels are high.

7. Community Similarity—is a comparison of a study site community to a reference site community. Similarity is often based on indices that compare community composition. Most community similarity indices stress richness and/or richness and abundance. Generally speaking, communities will become more dissimilar as stress increases.

***FISH AND PERIPHYTON POPULATION ASSESSMENTS***

Fish and periphyton population data were collected to supplement the macroinvertebrate biomonitoring data. Collection methods used to assess fish populations were in accordance with the *Preliminary Biological Monitoring and Assessment Protocols for Wadeable Rivers and Streams* (Tetra Tech 1995), and followed essentially a modified version of RBP Protocol V (Plafkin et al. 1989). Fish sampling was conducted by DWM biologists. The data analysis techniques, however, were qualitative only, as low diversity typical of the region precluded the use of biological indices for community analyses. Periphyton community assessments were qualitative as well, with DWM biologists conducting sampling and appropriate analyses. Periphyton sampling was conducted at the following macroinvertebrate kick sampling stations: TB02, KB02, KB10, RB01, WR01, BLK00A, BLK01, BLK02, BLK07, BLK15-1, BLK09-8A. Fish sampling was conducted at all tributary stations where macroinvertebrates were collected—KB09, TB02, RB01, BLK15-1, WR01, BLK09-8A. Prior to the 1998 biosurveys, these streams were "unassessed" by DEP for fish population data.

PERIPHYTON

During the summer of 1998, DEP personnel collected periphyton samples from a number of stations in the Blackstone River basin. The sampling was conducted as part of the macroinvertebrate and habitat assessments. Samples were typically collected in the riffle zone in areas of adequate light penetration (i.e., open or partially open canopy), and were usually taken from scrapes of one substrate type. The objectives of the periphyton sampling were limited in scope since only qualitative sampling was completed. Primarily, the periphyton data were collected to help describe the condition of the benthic communities, to determine what the predominating algae were, and to provide a record of the taxa that are found in Massachusetts.

Materials and Methods

Sampling was typically performed in an open-canopy riffle area. The sampling consisted of scraping rock and cobble substrates with a knife and collecting the material in a labeled glass vial. The samples were kept in an iced cooler and transported to the DWM laboratory in Worcester for identification.

A vial was shaken to get a uniform sample before sub-sampling. If filamentous algae comprised most of the sample they were removed first, identified separately and then the remainder of the sample was examined. An Olympus BH2 compound microscope with Nomarski optics was used for the identifications. Slides were typically examined under 200x power. A modified method for periphyton analysis developed by L. Bahls (1993) was used. Diatomaceous and "soft-bodied" periphyton were ranked according to their relative abundance and identified to genus. The soft-bodied algae are the green and blue-green algae. They do not require cleaning with acid in order to determine their identifying characteristics. The diatoms are algae with a hard, silaca-based cell wall. Typically, their contents must be treated and "digested away" with acid to allow for clear viewing of the diagnostic markings of the cell wall required for identification to genus or species. The scheme developed by Bahls for determining abundance is:

| | |
|---|---|
| R (rare) | fewer than one cell per field of view at 200x, on the average; |
| C (common) | at least one, but fewer than five cells per field of view; |
| VC (very common) | between 5 and 25 cells per field; |
| A (abundant) | more than 25 cells per field, but countable; |
| VA (very abundant) | number of cells per field too numerous to count. |

Analysis

The periphyton work afforded a qualitative assessment of instream water quality and habitats based on species composition and estimates of biomass. The information described above is critical for the determination of instream dominance. However, dominance alone does not provide all the information necessary to evaluate the impacts of algal growth on a stream. Information on the habitat and on the algal coverage is also helpful. The current field collection methods do not include quantitative assessment of algal cover. Any indication of the extent of algal cover in a particular reach is based on an estimate made during the habitat assessment. Areas with extensive algal growth are certainly identified in this manner, but areas in transition may be overlooked. This does limit the usefulness of the data; therefore, the analysis is limited to general comments regarding a particular site

FISH

Materials and Methods

Fish community (RBP V) sampling was conducted at each tributary station between 4 and 5 August 1998 by DWM using a battery-powered backpack electroshocking unit (Smith-Root™ Model 12). One pass was made in a representative stream reach (containing riffle, run, and pool habitat when available) measuring approximately 100 meters. Fish sampling commenced at the downstream riffle or other barrier (e.g., seine net, culvert, etc.) and proceeded upstream in side-to-side sweeps. Sampling was terminated at a constriction or other barrier to migration (such as a net) at the upstream end of the reach. Attempts were made to pick up all fish (except young-of-the-year) observed. All fish collected were held in plastic buckets for identification, enumeration, and subsequent release. Also noted and recorded on field sheets were general conditions of fish, including the presence of anomalies such as deformities, eroded fins, fungus, lesions, emaciation, and tumors. Voucher specimens were retained and preserved for later verification if field identifications were questionable.

Analysis

The RBP V protocol (Plafkin et al. 1989) calls for the analysis of the data generated from fish collections using an established Index of Biotic Integrity (IBI) similar to that described by Karr et al. (1986). Since no formal IBI exists for Massachusetts surface waters, the data provided by this sampling effort were used to assess the general condition of the resident fish population as a function of abundance and diversity.

## RESULTS AND DISCUSSION

The taxonomic list of macroinvertebrates collected at each sampling station is attached as an appendix (Table A1). Included in the taxa list are total organism counts, and the functional feeding group (FFG) and tolerance value (TV) of each taxon.

Summary tables of the RBP III data analyses, including biological metric calculations, metric scores, and impairment scores, are included in the Appendix as well. Table A2 is the summary table for all mainstem Blackstone River, Middle River, West River, and Mill River stations using BLK09-8A as the regional reference station. Table A3 is the summary table for those stations in the Blackstone River that were compared to an upstream (i.e., site-specific) control; thus, bracketing a known stressor (i.e., Worcester CSO facility; Upper Blackstone Water Pollution Abatement District discharge). Table A4 is the summary table for additional tributary stations when compared to the regional reference station KB10. Stations in the West River and Mill River were secondarily compared to the KB10 reference station as well. Habitat assessment scores for each station are also included in the summary tables, while a more detailed summary of habitat parameters is shown in Table A5. Finally, the appendix includes the taxa list for fish collected at all tributary biomonitoring stations (Table A6), and a list of periphyton taxa and relative abundance at selected biomonitoring stations (Table A7).

The 1998 biomonitoring data for this watershed generally indicate healthy aquatic communities and good habitat in most of the tributary streams examined, but likely point source-related problems in the mainstem Blackstone River.

### Mumford River

The Mumford River is a major tributary of the Blackstone River, encompassing approximately 57 square miles of land area in the Blackstone River basin in south central Massachusetts. The majority of the Mumford River watershed lies within four communities—Douglas, Northbridge, Sutton and Uxbridge. Two towns, Oxford and Webster, have a small amount (approximately one square mile) of land area in the Mumford River watershed (Dorlester 1994). Two major storage reservoirs (Whiten and Manchaug reservoirs) were constructed in the early 1800s in the headwaters of the Mumford River watershed to provide storage of spring runoff for release during the dry seasons of the year (Acheron 1985). These releases were initially used to power hydromechanical equipment in numerous mills along the river, and later powered hydroelectic turbines in many of the mills. The effect on streamflow was clearly documented by USGS gaging station records during the period from 1940 - 1951. By the early 1950s all of the hydromechanical and hydroelectric installations on the river were abandoned. The two reservoirs, however, were still operated with a shift in emphasis to flood control and low-flow augmentation. Residential development around the reservoirs also led to maintenance of the reservoir level for recreational purposes.

The Mumford River originates at the confluence of two unnamed tributaries flowing from the outlets of Tuckers and Stevens Ponds in Sutton. In the upper segment, the Mumford River is designated a Class B Warm Water Fishery, High Quality Water (MADEP and USEPA 1995). Downstream from the Douglas WWTP the Mumford River is designated as a Class B Warm Water Fishery (MADEP and USEPA 1995). It flows through the Gilboa Pond impoundment after which it receives the treated wastewater discharge from Guilford of Maine, Inc. before entering Lackey Pond. It continues its journey through four more impoundments (Meadow Pond, Linwood Pond, Whitin Pond and Caprons Pond) before joining the mainstem Blackstone River south of Route 16 in Uxbridge.
**BLK09-8A**—Mumford River, mile point 10.0, downstream from Manchaug Street, Douglas, MA.

Habitat

The sampling reach for DWM's Mumford River biomonitoring station began approximately 100 m downstream from Manchaug Street in Douglas. Fast water areas (i.e., "riffles") of varying depths dominated the reach, and coupled with an abundance of rocky substrates, provided excellent epifaunal habitat for macroinvertebrates and good cover for fish. Both stream banks were well-vegetated and stable,

with a fairly wide and undisturbed riparian zone along the left (north) bank. The riparian zone along the right (south) bank, however, was reduced due to the close proximity of a cemetery. Due to the narrow buffer between the cemetery driveway and river, NPS inputs in the form of excavated material (sand and gravel) and grass clippings along the bank posed a threat to the stream. In addition, the Manchaug Street road crossing may contribute to sediment deposition in the sampling reach. Riparian vegetation was dominated by red maple (*Acer rubrum*) with occasional red oak (*Quercus rubra*) and white pine (*Pinus strobus*). A shrub layer dominated by riverbank grape (*Vitis riparia*) occupied both banks. Instream vegetation was dominated by aquatic mosses, although submerged macrophytes (*Myriophyllum* sp., *Nasturtium* sp.) were observed as well. Instream algae, though minimal, consisted mainly of the green filamentous alga *Microspora* sp. (Table A7). BLK09-8A received a composite habitat score of 162/200—one of the highest received by a biomonitoring station in the Blackstone River watershed (Table A5). This was a designated regional reference station for the Blackstone River watershed survey by virtue of its high habitat evaluation, historically good water quality, and minimal upstream/adjacent land- use impacts (i.e., absence of point source inputs, lack of channelization, minimal development and agricultural activity nearby, undisturbed and well-vegetated riparian zone).

Benthos

Besides offering exceptional habitat, this reach of the stream was characterized by a macroinvertebrate assemblage indicating a healthy aquatic community. A richness of 28 different taxa was recorded—the most of any biomonitoring station in the basin—and most of the metric values were strongly indicative of clean water and "best attainable" conditions (Table A2). In particular, those attributes that measure components of community structure (i.e., taxa richness, biotic index, EPT index)—which display the lowest inherent variability among the RBP metrics used (Resh 1988)—scored well, further corroborating the designation as a reference station. A biotic index of 4.04 was quite low relative to the other biomonitoring stations in the survey, indicating the dominance of the Mumford River benthos assemblage by highly pollution-sensitive taxa. BLK09-8A received a total metric score of 42/42 (Table A2).

Results of the fish population assessment conducted at BLK09-8A indicated an assemblage that was fairly diverse relative to other tributary biomonitoring stations in the watershed (Table A6). Eight fish species were collected, the majority of which are considered moderately tolerant to environmental perturbations (Simon 1999). Four brook trout—considered intolerant of environmental stress—were collected as well; however, these individuals may have been stocked by DFWELE (DeCesare, MADEP, personal communication).

**Middle River**

The Middle River is formed by the confluence of Kettle, Beaver, and Tatnuck brooks in a highly urbanized portion of Worcester. A short distance dowstream from this confluence, the Middle River receives the discharge from Mill Brook. Mill Brook originates at Salisbury Pond in Worcester and flows through an underground conduit, draining the northern section of the city, until converging with the Middle River. It is at this confluence that the mainstem Blackstone River begins.

**BLK00A**—Middle River, mile point 49.2, downstream from Riley Research, Inc. footbridge, Worcester, MA.

*Habitat*

The BLK00A sampling reach began approximately 100 m downstream from the footbridge to Riley Research, Inc. and about 0.50 km downstream from Interstate 290 in Worcester. A variety of velocity-depth combinations and abundant rocky substrates provided macroinvertebrates with good habitat throughout the reach. Fish cover was somewhat less than optimal, although there was a mix of stable habitat along much of the left (east) bank. Both stream banks were stable and well-vegetated; however, riparian vegetative zone width was much reduced along the left bank due to the close proximity of a manicured lawn on the property of Riley Research. The riparian zone along the right (west) bank was fairly well-vegetated with ash (*Fraxinus americana*) and maple (*Acer spp.*), hydrophyllic grasses, and the herbaceous jewelweed (*Impatiens capensis*). Also dominating the herbaceous layer was the non-native Japanese knotweed (*Polygonum cuspidatum*)—possibly indicative of historical disturbances to the riparian zone. A shrub layer was sparse and confined to the right bank as well, with buttonbush (*Cephalanthus occidentalis*), elderberry (*Sambucus canadensis*), and alder (*Alnus* sp.) represented. Though not abundant, filamentous forms of green algae (*Scenedesmus* sp., *Stigeoclonium* sp.) and diatoms (*Melosira* sp., *Cymbella* sp.)—some of which may be indicative of organic enrichment (Palmer 1962)—were observed throughout the reach (Table A7).

BLK00A received a total habitat assessment score of 143/200 (Table A5). Total score reduction was mostly affected by the low score for sediment deposition, which was quite substantial throughout the sampling reach. Sediment inputs that resulted in shifting sand bars and moderate deposition of fine sediments in pools may originate from the highway crossing upstream or other sources. Other potential NPS inputs are related to the close proximity of the adjacent park/lawn near Riley Research. Instream turbidity, probably the result of various forms of urban runoff, was also noticed during the time of the biosurvey.

*Benthos*

The BLK00A macroinvertebrate assemblage received a total metric score of 14, representing 33% comparability to the reference conditions at BLK09-8A and placing the benthos in the "moderately impaired" category (Table A2). Unlike the 1977 and 1985 biosurveys in the Middle River, when the hyper-abundance of chironomids and tubificid worms indicated heavy organic loadings, the sample collected in 1998 was dominated by the filter-feeding caddisfly Hydropsychidae and fingernail clam Pisidiidae. This dense filter-feeding assemblage at BLK00A appears to reflect the effects of moderate organic enrichment, and is indicative of an unbalanced community responding to an overabundance of a food resource—in this case fine particulate organic matter (FPOM). The low scoring scrapers/filterers metric (score: 0) also corroborates that the FPOM has displaced periphyton as a food resource at BLK00A (Table A2). In addition, the low taxa richness, reduction of EPT taxa, and especially the high biotic index indicate potentially low levels of dissolved oxygen (Table A2). The presence of filter-feeders at BLK00A is significant with regard to toxic effects. As this feeding group is very sensitive to toxicants bound to fine particles, it is the first to decline when exposed to a steady source of such bound toxicants (Plafkin et al. 1989). That filter-feeding taxa dominated the BLK00A benthos assemblage during the 1998 survey suggests that toxic impacts that may have threatened biological potential in this portion of the river during past surveys probably are no longer a factor.

Although biological integrity at BLK00A remains less than ideal, water quality conditions have probably improved here since the 1977 and 1985 biosurveys, when possible toxic impacts/gross organic pollution and severe organic enrichment were documented during the respective surveys. It should be noted that as with the 1985 survey, the density of macroinvertebrates in the 1998 sample taken at BLK00A was very low—probably the result of habitat and/or water quality limitations.

Despite its designation prior to the 1998 biosurvey as the upstream reference station for BLK01, the considerable impairment of the aquatic community at BLK00A probably deems the station inappropriate for upstream-downstream comparisons—in this case the bracketing of Mill Brook. The ability to discern impacts to communities downstream from point source pollution becomes diminished when the

community upstream is degraded as well (Beckett and Keyes 1983). Thus, while comparisons of the BLK00A benthos to the downstream community at BLK01 are included in Table A3, greater emphasis should be placed on comparisons to the regional reference station BLK09-8A when evaluating biological potential at BLK01.

**Blackstone River**

From its origin in Worcester, the Blackstone River, a Class B Warm Water Fishery (O'Shea 1991), flows southeastward and through numerous impoundments for a distance of approximately 29 miles (49 km) to the corporate boundary between Massachusetts and Rhode Island, and then on to Providence and Narragansett Bay. The 540 square mile (1404 $km^2$) total drainage area of the Blackstone River includes 335 square miles (871 $km^2$) within the Massachusetts counties of Bristol, Middlesex, Norfolk, and Worcester. Major tributary catchment areas of the Blackstone River include those of the Quinsigamond (38 $mi^2$; 86 $km^2$), West (30 $mi^2$; 78 $km^2$), Mumford (57 $mi^2$; 148 $km^2$), and Mill (33 $mi^2$; 86 $km^2$) rivers (Johnson et al. 1992).

**BLK01**—Blackstone River, mile point 47.9, downstream from Millbury Street, Worcester, MA.

*Habitat*

Station BLK01 at Millbury Street was located approximately 0.4 mile (0.6 km) downstream from the confluence with Mill Brook which receives the discharge from the Worcester CSO facility. The partially-shaded, channelized sampling reach began approximately 200 m downstream from Millbury Street in an area of much commercial and industrial development. Despite its urban setting, the reach offered an abundance of rocky substrates immersed in riffle areas of varying depths and provided macroinvertebrates with excellent epifaunal habitat. Fish habitat was somewhat less than optimal, with little cover available in the way of woody debris, snags, and other stable habitat. Both stream banks were well-vegetated and stable, with slabs of granite "rip-rap" providing additional stability along much of the right (west) bank. Riparian zone width was much reduced along both banks, with only a few meters of vegetative buffer between the channel and adjacent parking lots. Riparian vegetation consisted mostly of trees, with ash (*Fraxinus rubrum*), weeping willow (*Salix babylonica*), slippery elm (*Ulmus rubra*), and cottonwood *(Populus deltoides*) present. Other forms of woody and herbaceous growth, represented by poison ivy (*Rhus radicans*), Japanese knotweed (*Polygonum cuspidatum*), and hydrophyllic grasses, were also common. Instream algal growth, while minimal, was dominated by diatomaceous forms (especially *Melosira* sp.) known to thrive in organically enriched conditions (Palmer 1962) (Table A7).

NPS inputs in the form of trash were noted both instream and along both banks. The dumping of debris from the Millbury Street road crossing and the adjacent stream banks appears to be an historical and ongoing problem. Sand deposits were observed throughout the reach, possibly originating from the Millbury Street crossing or elsewhere. At the time of sampling, moderate levels of turbidity, possibly caused by the heavy loads of organic sediments or suspended organic material often associated with eutrophic conditions, were observed at BLK01 as well. These fine materials can be deleterious because they can reduce light penetration and, consequently, plant growth (instream aquatic vegetation was minimal at BLK01), smother hard surfaces, and fill interstices within the substrate (Wiederholm 1984). Resident biota at BLK01, then, may be subsequently affected by obstructions in food collection or respiration caused by fine deposits of organic material. BLK01 received a total habitat score of 142/200 (Table A5).

Benthos

Compared to the upstream "reference" station at BLK00A, the total metric score for the BLK01 benthos assemblage was 30% comparable (Table A3). However, because the BLK00A community is structured in response to considerable organic enrichment and is obviously impaired itself, conditions at BLK01 may in fact be worse than scores based on upstream comparisons indicate. Using the Mumford River station to represent the "best attainable" conditions in the watershed, BLK01 received a total metric score of only 6 (Table A2). The BLK01 community was dominated by midges and oligochaete worms to the exclusion, or near exclusion, of other groups (Table A1). Values for the biotic index (8.74) and EPT index (0) were particularly troubling, and contributed to the low comparability (14%) to reference conditions and the

severely impaired condition (Table A2). In fact, the biotic index for the BLK01 assemblage was the highest of all the biomonitoring stations surveyed in 1998, and the EPT index was the lowest received by a biomonitoring station—clearly indicative of a severely stressed and highly pollution-tolerant community subjected to heavy organic loadings and potentially-low instream dissolved oxygen levels. In addition, the extremely low densities of organisms in the sample (sorting through 32 grids was necessary before attaining the 100-organism target number!)—despite the excellent epifaunal habitat available—suggests oxygen depletion and/or possibly the presence of a toxicant. Studies by Beckett and Keyes (1983), among others, support the contention that aquatic habitats subjected to toxic wastes generally possess communities characterized by low taxa richness and low densities. The conspicuous absence of filter-feeders—normally expected in a reach with such an abundance of dissolved organic matter (DOM) and subjected to good current velocity—further suggests toxic effects at BLK01. By readily adsorbing to DOM forming FPOM during processes such as flocculation, toxicants become available to filter-feeders via the FPOM food resource (Plafkin et al. 1989). As a result, densities of filter-feeders are expected to decline when exposed to toxic stressors (Weiderholm 1984).

While the Worcester CSO facility on Mill Brook seems the most significant source of organic pollutant loadings to this portion of the Blackstone River, the inability to successfully bracket Mill Brook using an adequate upstream control makes it difficult to "tease out" other potential sources of organic enrichment that may enter the river from Mill Brook or farther upstream in the mainstem. Indeed, a degraded community upstream from the Mill Brook confluence indicates the presence of organic enrichment upstream from BLK01 as well. However, the effects of enrichment—as reflected in the extremely stressed BLK01 community—appear to become more severe immediately downstream from the Mill Brook confluence, suggesting that the Worcester CSO continues to exacerbate the degraded water quality conditions that have persisted in this portion of the Blackstone River. Indeed, water quality data collected by DWM during the 1998 survey found elevated levels of bacteria (1100 cfu/100 ml) and phosphorus (> 0.05 mg/l), possibly indicative of sewage inputs (MADEP 1998). It is difficult to determine whether biological integrity at BLK01 has improved since the previous survey conducted in 1977, when river conditions were "so deplorable, that no quantitative sampling was attempted," and qualitative sampling found the macroinvertebrate community to be indicative of severely polluted conditions (Johnson et al. 1992). Regardless, abatement of the stormwater/combined sewer overflow in Mill Brook by the City of Worcester does not seem to be having a positive impact on the biological health of the Blackstone River system.

**BLK02**—Blackstone River, mile point 46.0, downstream from McCracken Road, Millbury, MA.

*Habitat*

The BLK02 sampling reach began approximately 175 m downstream from McCracken Road in Millbury, where the river is crossed by high-tension power lines. The reach was somewhat pool-dominated, with occasional short riffle areas. Cobble and gravel substrates were common, although considerable sedimentation was evident along much of the reach, causing significant embeddedness of substrates. Despite good channel depth, cover for fish was marginal at best due to lack of stable habitat and moderate deposition of sand in pool areas. Both banks were fairly well-vegetated, save for the lower portion of the reach where vegetation has been obviously cleared for the existing power lines. Stability was good along both banks, with "rip-rap" providing additional reinforcement. Riparian zone width was slightly reduced, with trees—especially ash (*Fraxinus americana*), silver maple (*Acer saccharinum*), and white birch (*Betula papyrifera*)—the dominant form. Instream aquatic vegetation was extremely abundant and possibly indicative of nutrient loadings associated with a municipal wastewater discharge, with the rooted submergent *Myriophyllum* sp. and rooted floating *Callitriche* sp. most common. Indeed, elevated levels (0.34 mg/l) of phosphorus were documented here during the 1998 DWM water quality survey (MADEP 1998). Other than the filamentous green alga *Stigeoclonium* sp. (Table A7) whose presence is often associated with organic enrichment (Palmer 1962), virtually no instream algae were observed in the reach, which was surprising considering the open canopy and nutrient availability. Slight turbidity in the water column was noted during sampling.

NPS pollution consisted mainly of trash and debris associated with the adjacent railroad tracks along the right (west) bank. In addition, a large (1.5 m) culverted pipe enters the river at the top of the reach but was not discharging at the time of the survey. Of greatest concern was the considerable amount of sand

deposited throughout the reach, resulting in shifting bars and deposition in pools. A massive public works project (now complete) just upstream from the sampling reach, in which the creation of a new highway interchange resulted in large deposits of excavated materials adjacent to the river, was the most likely cause of sediment inputs to this portion of the river. An investigation into the efficacy of pre-existing nonpoint source pollution-related Best Management Practices (BMPs), or the implementation of new BMPs, associated with this project is recommended. BLK02 received a total habitat assessment score of 137/200 (Table A5).

Benthos

The BLK02 macroinvertebrate assemblage was highly comparable (95%) to upstream conditions at BLK01 (Table A3)—hardly a positive attribute considering the degraded conditions at Millbury Street. As stated earlier, greater emphasis should be placed on the evaluation of BLK02 based on comparisons to reference conditions at BLK09-8A rather than the impacted "control" station at BLK01. With that said, the BLK02 benthos received a total metric score of 8, representing 19% comparability to BLK09-8A and placing the station in the "severely impaired" category for biological condition (Table A2). The unbalanced macroinvertebrate community at BLK02 was dominated by taxa highly tolerant of conventional organic pollution, especially chironomids and oligochaete worms (Table A1), contributing to one of the highest biotic indices (7.82) in the 1998 survey. Other metrics scoring poorly—and indicative of organic enrichment—were EPT index (score: 0), scrapers/filterers (score: 0), EPT/Chironomidae (score: 0), and community similarity (score: 0). The predominance of midges and worms seen during the 1998 survey is reminiscent of both the 1985 and 1991 biosurveys, when their high densities were thought to be related to toxic effects of ammonia and chlorine respectively, and originating from the UBWPAD or other more upstream sources (e.g., Worcester CSO facility) (Johnson et al. 1992; Szal 1992). Despite recent effluent upgrades (i.e., nitrification, dechlorination) at the UBWPAD, water quality monitoring during DWM's 1998 survey found elevated levels (0.20 mg/l) of ammonia to persist at BLK02 (MADEP 1998). In addition, the abundance of the chironomid *Cricotopus bicinctus* in the 1998 benthos sample is significant. That this taxon has been shown to display resistance to contamination by heavy metals and chlorine suggests possible toxic impacts to the BLK02 biota (Beckett and Keyes 1983; Simpson and Bode 1980). Interestingly, high densities of *Cricotopus sp.* were also documented during DEP's 1985 biosurvey at McCracken Road and were attributed to the UBWPAD discharge or other unknown sources (e.g., New England Plating, Inc.) of contamination, while the 1991 survey found *Polypedilum* sp. to dominate the chironomid population (Johnson et al. 1992; Szal 1992). That 25% of the BLK02 assemblage sampled during the 1998 survey consisted of *Cricotopus bicinctus*, yet none were present at the upstream station BLK01, suggests that the stressor affecting their presence is located between the two stations–the UBWPAD being the likeliest source of perturbation. Metals data collected during DEP's 1991 water quality survey of the Blackstone River revealed elevated levels of cadmium, copper, and nickel immediately downstream from the UBWPAD discharge (Hartman 1992); however, sampling for metals at BLK02 during the 1998 water quality survey—which might have corroborated suspected metals toxicity during this biosurvey—was not conducted.

It would appear, then, that habitat degradation in the form of sedimentation, coupled with water quality degradation from severe organic enrichment and possible toxicants, continue to compromise biological integrity in this portion of the Blackstone River. Due to the lack of a suitable reference condition (i.e., upstream control) immediately upstream from the UBWPAD discharge, yet downstream from other potential factors that may influence community structure at BLK02 (BLK01 was upstream from highway construction activities and the confluence with the Kettle Brook overflow channel) it is difficult to isolate the exact sources of anthropogenic impacts to BLK02. While the UBWPAD is a likely cause of impairment to the BLK02 aquatic community, biological degradation is probably exacerbated by additional upstream sources of pollutant loadings, most notably the Worcester CSO facility.

**BLK07**—Blackstone River, mile point 36.8, downstream from Sutton Street, Northbridge, MA.

*Habitat*

The BLK07 sampling reach was located approximately 150 m upstream from Sutton Street in Northbridge, in an industrialized and channelized (stone wall replacing left/north bank; "rip-rap" along right/south bank) portion of the Blackstone River. Swift current velocity and considerable depth (> 1.0 m) in some areas, coupled with large rocky substrates, presented a challenge to kick-sampling but offered excellent epifaunal habitat for macroinvertebrates. Fish habitat was marginal at best due to lack of cover and stable habitat. Both stream banks were well-vegetated, with rip-rap and walled banks providing obvious stability. Riparian vegetation, consisting of a few scattered oaks (*Quercus* spp.) and red maples (*Acer rubrum*), was extremely reduced due to the channelized conditions mentioned above. Instream vegetation was abundant, consisting of dense beds of rooted submergent *Sagitaria subulata* and the streaming green alga *Ulothrix zonata* (Table A7).

The narrow vegetative buffer, coupled with the close proximity of adjacent industrial/commercial activity, increases the potential for NPS inputs to the reach. Heavy deposits of sand were observed near the top of the sampling reach—origins of instream sedimentation are unknown; however, serious erosion of the right bank was evident immediately upstream from the reach. Turbid instream conditions and an obvious odor of treated sewage were observed during the biosurvey. BLK07 received a total habitat assessment score of 123/200 (Table A5). This was the lowest habitat score received by a biomonitoring station during the 1998 survey, with sediment deposition, severe channelization, and reduced riparian zone width affecting the score most negatively.

Benthos

The benthos assemblage at BLK07 received a total metric score of 12, representing 29% comparability to the regional reference station BLK09-8A and placing the community in the "moderately impaired" category (Table A2). Biological condition appears to have improved slightly compared to biomonitoring stations farther upstream, with taxa richness comparable to reference conditions (Table A2). However, a biotic index of 7.63 and an EPT index of only 2 imply a stressed biological community. While the low habitat evaluation at BLK07 makes it difficult to discriminate habitat effects from water quality effects, the predominance of chironomids and tubificid worms suggests a community structured in response to organic pollutant loadings and associated enriched conditions in this portion of the river. Upstream point source discharges—specifically, wastewater treatment facilities in Millbury and Grafton—probably contribute most of the organic pollutant loadings responsible for enrichment effects in this portion of the Blackstone River. In addition, the UBWPAD facility may still contribute organic loadings this far downstream due to the large volume of its effluent. It should be noted that elevated ammonia (0.21 mg/l) and phosphorus (0.34 mg/l) levels, probably associated with effluent, were documented by DWM during the 1998 water quality survey (MADEP 1998).

Water quality and biological conditions at BLK07 have probably improved since the 1985 biosurvey, when the tolerant midge *Cricotopus sp.* dominated the benthos assemblage and suggested the presence of an unknown toxicant (Johnson et al. 1992). It is unclear, however, if conditions have improved here since the 1991 biosurvey. The benthos sample collected in 1991 was hyperdominated by hydropsychid caddisflies (Szal 1992). Referred to as "net-spinners," hydropsychids construct sizeable silken nets from which they filter and collect organic food matter in the form of algae and fine suspended particulates from the water column. Their predominance in 1991 was attributed to the numerous upstream impoundments, coupled with an abundance of instream nutrients that favor the production of phytoplankton and other algal matter in these impounded areas. As algae and various forms of organic matter make their way over impoundment dams, they become available to filter-feeders such as Hydropsychidae as a high quality food resource. That filter-feeders such as Hydrosychidae did not hyperdominate the 1998 benthos assemblage suggests either a response to decreasing concentrations of organic matter, or more likely, a change in form (i.e., size) of the suspended organic particles most utilized by hydropsychids.

**BLK12A**—Blackstone River, mile point 24.5, upstream from Central Street, Millville, MA.

*Habitat*

The BLK12A sampling reach began immediately upstream from Central Street in Millville, where a small island splits the river into two channels of high-velocity water. Sampling was conducted in the southernmost channel, as it offered easier access for kick-sampling and better benthic habitat than the opposite channel. Riffle areas of varying depth dominated each end of the reach, while slower water (i.e., runs/pools) comprised the middle. Boulder and cobble substrates were found throughout the entire reach, and an abundance of aquatic mosses probably offered additional epifaunal habitat. The combination of deep water and large substrates offered excellent fish cover as well. Both banks were well-vegetated and stable; Riparian vegetation was undisturbed and wooded, with red maple (*Acer rubrum*), red oak (*Quercus rubra*), elm (*Ulmus* sp.), and willows (*Salix* sp.) extending from the grassy margin of the left (south) bank. Riparian zone width was slightly reduced along the right (north) bank, with the exotic Japanese knotweed (*Polygonum cuspidatum*) common and possibly indicative of past disturbances. There was no evidence of past or present NPS pollution. BLK12A received a total habitat assessment score of 167/200—slightly higher than that of the reference station and easily the highest habitat evaluation received by a mainstem station (Table A5).

Benthos

The BLK12A macroinvertebrate assemblage received a total metric score of 10, representing 24% comparability to reference conditions at BLK09-8A (Table A2). While it was anticipated that recovery of the aquatic community would be observed in this portion of the Blackstone River, the benthos assemblage remained in the "moderately impaired" category. Scores for taxa richness and percent dominant taxon metrics were actually lower than the upstream station BLK07, and were the result of an imbalanced community dominated by the filter-feeding caddisfly Hydropsychidae. The preponderance of hydropsychids (52% relative abundance) and associated FPOM at BLK12A is not unlike the assemblage observed during the 1991 biosurvey (Szal 1992). In addition, periphyton-dependent taxa—which became an important component of trophic structure at Central Street during the 1991 biosurvey—continued to be seen during the 1998 survey. Though not as common as in 1991, mayflies appear here for the first time in the mainstem Blackstone River (Table A1). Part of the scraper fuctional feeding group, mayflies such as Heptageniidae graze on thin layers of periphyton that are attached to rocky substrates. Generally considered pollution-sensitive, their presence in this portion of the river indicates possible improvements in water quality. That the EPT index (5) is higher at BLK12A than any of the other Blackstone or Middle River stations also suggests slight improvements. Furthermore, the biotic index at BLK12A reaches its lowest level among all mainstem stations, indicating a reduction in organic enrichment in this portion of the Blackstone River. Indeed, ammonia levels documented by DWM (MADEP 1998) have decreased at BLK12A compared to the BLK07 station upstream; however, phosphorus levels remain somewhat elevated and may contribute to the proliferation of the FPOM food resource here. The combined effects of municipal point source discharges immediately upstream (Northbridge WWTP, Uxbridge WWTP) and/or other point sources farther upstream probably contribute most to water quality degradation at BKL12A.

**West River**

From the confluence of its headwater streams, Miscoe and Warren brooks, the West River flows in a generally southerly direction before joining with the Blackstone River in Uxbridge. The West River sub-basin drains a 30 square mile area of mostly undeveloped land—much of it occupied by Upton State Forest and extensive wetlands. The U.S. Army Corps of Engineers maintains West Hill Dam on the West River in Uxbridge for flood control purposes.

**WR01**—West River, mile point 7.6 (approx.), upstream from West River Road, Upton, MA

*Habitat*

The WR01 sampling reach began approximately 40 m upstream from West River Road in Upton, in a maple-dominated (*Acer rubrum*) portion of Upton State Forest. The abundance of rocky substrates subjected to a variety of flow regimes provided macroinvertebrates with excellent epifaunal habitat. In addition, deep pools, snags and other woody debris, and boulders offered optimal fish habitat throughout the reach. Instream vegetation was rooted (*Callitriche* sp., *Sparganium* sp.) and confined to the lower portion of the sampling reach, where sunlight penetrated the tree canopy most. Filamentous green algae, most notably *Ulothrix* sp. and *Mougeotia* sp., were restricted to this area as well. A well-vegetated and stable right (east) bank gave way to an undisturbed and densely wooded riparian zone; however, the steepness of the left (west) bank resulted in areas of sloughing and denuded vegetation (i.e., "raw areas") along the entire reach. Despite the eroding nature of the left bank, however, instream effects (e.g., sediment deposition, embeddedness) were not evident. The close proximity of a mowed lawn (and adjacent house) near the top of the left bank led to point reductions for riparian vegetative zone width and was a potential source of NPS inputs. Nevertheless, the total habitat assessment score (172/200) for WR01 was higher than that received by the primary reference station BLK09-8A, and one of the highest received by a biomonitoring station in the 1998 survey (Table A5).

Benthos

The benthos assemblage at WR01 received a total metric score of 28, representing 67% comparability to its primary reference station BLK09-8A (Table A2). Yet, despite the placement of the community in the "slightly impaired" category for biological condition, several of the metrics—including richness, EPT index, and EPT/Chironomidae—scored as well as, or better than, metrics for the reference condition in the Mumford River (Table A2). Scoring lowest was the percent community similarity metric—possibly attributed to the differing effects of hydrology and habitat on the communities at WR01 and BLK09-8A. While instream/riparian habitat and flow regimes appeared similar within both sampling reaches, the forested stream system just upstream from BLK09-8A may offer different food resources to the immediate downstream aquatic community than at WR01, which is somewhat atypical of the low gradient wetland nature of the majority of the West River system. The extensive wetland margins upstream from WR01 may offer substantial organic inputs in the form of allochthonous materials and may support a somewhat different trophic guild (i.e., filter-feeder/FPOM-based) here than at BLK09-8A (i.e., scraper/periphyton-based).

When compared to the reference station in Kettle Brook (KB10), the WR01 benthos assemblage received a total metric score of 34, representing 81% comparable to the "best attainable" conditions in the watershed (Table A4). Most metrics, including taxa richness, biotic index, and EPT index, received the highest score possible and were indicative of "non-impaired" biological conditions and good water quality (Table A4). The only metric to score poorly for the WR01 assemblage was community similarity (score: 0), which again may be attributed to differences in habitat and associated organic inputs immediately upstream from both sampling reaches that may affect trophic and community structure within each station. The abundance of shredders at KB10 is indicative of substantial CPOM inputs to the sampling reach, whereas high densities of gatherers and filterers at WR01 suggests finer organic materials are a primary food resource (Table A1).

The fish assemblage collected at WR01 was the most diverse observed in the 1998 Blackstone River watershed survey (Table A6). The fact that several taxa (e.g., trout, tesselated darter, chain pickerel) encountered at WR01 are not normally associated with impaired waters further corroborates good overall health of the aquatic community here.

Based on a taxa-rich aquatic assemblage (macroinvertebrates and fish) dominated by many pollution-sensitive forms relative to reference conditions in both the Mumford River and Kettle Brook, it appears that biological integrity is good in this portion of the West River and remains unaffected by point source inputs farther upstream. Though perhaps atypical of the majority of the West River sub-basin in terms of community structure and function, the WR01 sampling reach supports a diverse assemblage of aquatic life, and should continue to be monitored and protected.

**Mill River**

From its source in North Pond in Hopkinton, the Mill River flows in a southerly direction, draining a 33 square mile catchment area consisting of numerous impoundments and tributaries before joining the Blackstone River in Woonsocket, Rhode Island. With the exception of the towns of Hopedale and Milford, much of the sub-basin remains only lightly developed. A municipal wastewater treatment facility (Hopedale WWTP), numerous sand and gravel operations, and various NPS perturbations are potential threats to biological potential in the Mill River system.

**BLK15-1**—Mill River, mile point 3.0, downstream from Summer Street, Blackstone, MA

*Habitat*

The BLK15-1 station began approximately 200 m downstream from Summer Street in Blackstone. The sampling reach was fairly homogenous in terms of flow regime, dominated by swift moving runs and occasional shallow riffle areas consisting of an equal mix of cobble, gravel, and sand. As with epifaunal macroinvertebrate habitat, fish cover was optimal and consisted of a variety of stable habitats (snags, overhanging bank vegetation, pools). Both banks were stable and extremely well-vegetated. Riparian vegetative zone width was also good, especially along the right (west) bank, where a diverse shrub layer consisting of alder (*Alnus* sp.), elderberry (*Sambucus canadensis*), dogwood *(Cornus sp.),* riverbank grape *(Vitis riparia),* sweet pepperbush (*Clethra alnifolia*), and *Rhododendron* sp. gave way to a maple-dominated (*Acer rubrum*) hardwood forest. The riparian zone along the left (east) bank was only slightly reduced, giving way to meadow near the top of the reach and oak-dominated (*Quercus* sp.) upland forest near the bottom of the reach. Instream vegetation was scarce, with occasional patches of the rooted submergent arrowhead (*Sagittaria* sp.) and minimal periphyton (*Fragilaria* sp. was dominant diatom) present (Table A7).

BLK15-1 received a total habitat assessment score of 168/200, which was higher than that received by the primary reference station BLK09-8A (Table A5). The only habitat parameters to score poorly were sediment deposition and embeddedness, the result of considerable deposits of sand observed throughout the reach (Table A5). Instream deposition threatens biological integrity by filling in productive epifaunal microhabitat utilized by invertebrates as refugia and/or fish for egg incubation. Possible sources of instream sedimentation are the erosional activity of naturally-sandy flood plain soils in the sub-basin, or NPS inputs (e.g., from the upstream road crossing). Certainly, the presence of numerous sand and gravel operations adjacent to the river are potential NPS stressors, and their activities may warrant further investigation (i.e., site visits).

Benthos

When compared to its primary reference station (BLK09-8A), the BLK15-1 benthos assemblage received a total metric score of 34, representing 81% comparability to reference conditions and placing the community in the "non-impaired" category (Table A2). Compared to its secondary reference station at KB10, BLK15-1 again received a total metric score of 34, resulting in 81% comparability to reference conditions and a "non-impaired" designation for biological condition (Table A4). The macroinvertebrate assemblage was characterized by a diversity of taxa, including greater richness of intolerant EPT taxa than at either reference station (Table A2 and A4). And while the grazing elmid beetle *Optioservus* sp. dominated (27% relative abundance) the benthic sample, this is a fairly pollution-sensitive taxon whose plastron respiration requires well-oxygenated instream conditions (Merritt and Cummins 1996; Peckarsky et al. 1990). The high densities of Elmidae and other scrapers at BLK15-1 contributed to the high scraper/filterer metric value (Table A2 and A4), further corroborating the importance of periphyton—rather than suspended particulate organic material—as a food resource at BLK15-1. Furthermore, low biotic index values relative to either reference condition indicate the absence of enrichment effects in this portion of the Mill River.

Fish sampling at BLK15-1 resulted in the collection of 8 different taxa (Table A6). This was the second most diverse assemblage sampled during the 1998 surveys, and included two pollution-sensitive brown trout (*Salmo trutta*).

Biological integrity at BLK15-1 appears to have shown marked improvements, especially in terms of trophic and community structure, compared to previous biological surveys. The hyperdominance of filter-feeding hydropsychids observed during the 1985 survey contributed to a benthos assemblage considered "slightly impacted", and was indicative of excessive organic enrichment, possibly the result of point source discharge effects (Johnson et al. 1992). Hydropsychids once again dominated the benthic community during the 1991 biosurvey, although other feeding groups—most notably the scraper Heptageniidae—were represented as well (Szal 1992).

**Kettle Brook**

The largest of the Blackstone River headwater streams, Kettle Brook originates from a series of four water supply reservoirs located in the towns of Paxton and Leicester. From Kettle Brook Reservoirs No. 1-4, the stream flows in a southerly direction through generally open space. Land- use becomes increasingly urbanized as Kettle Brook approaches the Worcester City limit, veering in a northerly direction and picking up the discharge of Dark, Tatnuck, and Beaver brooks before joining the Middle River.

**KB10**—Kettle Brook, mile point 60.7, downstream from Earle Street, Leicester, MA

*Habitat*

KB10 began 300 m downstream from Earle Street in Leicester, approximately midway between Kettle Brook Reservoirs No. 1 and No. 2. A picturesque portion of the sub-basin, the open-canopied sampling reach meandered through a vast "wet" meadow area that graded quickly into upland forest. The reach was virtually one continuous and strikingly clear riffle area dominated by cobble and boulder substrates. The combination of fast water and rocky substrates provided excellent epifaunal habitat for macroinvertebrates, while the somewhat homogenous and shallow instream conditions provided fish with slightly less than optimal cover. Both banks were well-vegetated and stable. Riparian vegetation extended undisturbed from both banks, first dominated by herbaceous growth (*Eupatorium* sp.= Joe-Pye weed, *Osmunda* spp.= ferns) and grasses (*Carex* sp., *Panicum* sp., hydrophyllic forms) before giving way to a dense upland forest of red maple (*Acer rubrum*), red oaks (*Quercus rubra*), and pines (*Pinus* sp.). Despite the open canopy along the entire reach, instream vegetation was minimal and consisited of a few patches of filamentous green algae (*Spirogyra* sp., *Rhizoclonium* sp.) and cyanobacteria (*Lyngbya* sp.) (Table A7). Naturally unproductive instream conditions, often the case in headwater streams such as this, may be responsible for the suppression of the periphyton community at KB10.

KB10 received a composite habitat score of 179/200—the highest received by a biomonitoring station in the Blackstone River watershed (Table A5). This was the designated regional reference station for tributary stations in the Blackstone River watershed survey by virtue of its high habitat evaluation, presumed good water quality, and minimal upstream/adjacent land use impacts (i.e., absence of point source inputs, lack of channelization, minimal development or agricultural activity nearby, undisturbed and well-vegetated riparian zone, minimal NPS inputs).

Benthos

The benthic community encountered at KB10 reflected the excellent habitat and water quality in this portion of Kettle Brook. A diverse assemblage of clean-water taxa dominated the sample, including three species of stoneflies (Plecoptera), generally considered the most pollution-sensitive insect order. KB10 received a total metric score of 42 (Table A4). The balanced trophic structure and optimum community structure (composition and dominance) found at KB10 corroborate its use as a regional reference station. Biological integrity appears to have remained optimal here since the last biological survey conducted in 1977, when a diverse macroinvertebrate communtity dominated by intolerant taxa was documented (Johnson et al. 1992).

**KB09**—Kettle Brook, mile point 58.2, downstream from Auburn Street, Leicester, MA

*Habitat*

KB09 began approximately 400 m downstream from Auburn Street in a residential section of Leicester. The sampling reach meandered considerably through an area of maple-dominated upland forest. Well-developed riffle areas dominated by cobble and gravel substrates offered excellent epifaunal habitat for macroinvertebrates. In addition, an abundance of boulders, snags, and other stable habitat afforded optimal cover for fish. Both stream banks were well-vegetated and moderately stable, with occasional small areas of erosion evident. Riparian vegetative zone width was optimal along both banks, extending undisturbed in both directions. Riparian vegetation was dominated by red maple (*Acer rubrum*); however, silky dogwood (*Cornus stolonifera*), Japanese knotweed (*Polygonum cuspidatum*), and ferns (*Osmunda* sp.) comprised a somewhat sparse shrub/herbaceous layer as well. Instream vegetation and algae were virtually absent, possibly due to the shaded nature of the reach and/or lack of nutrients.

KB09 received a total habitat assessment score of 162/200 (Table A5). Point reductions for channel flow status affected the assessment score the most, the result of low water levels and associated substrate exposure. The exposed cobble bars and stream margins present during the biosurvey at KB09 were dramatically different than instream conditions observed during field reconnaissance (conducted 25 June 1998), when water reached the base of both banks and minimal channel substrates were exposed. Base flow at KB09 was further reduced during the time of fish population sampling in August.

Recent NPS pollution inputs to the KB09 sampling reach were not observed; however, an abundance of trash throughout the reach suggests the historical dumping of trash in this stream segment. Broken glass, bricks, scrap metal, and other forms of urban debris were observed during the biosurvey, making this portion of Kettle Brook a good candidate for stream clean-up efforts.

Benthos

The KB09 benthos assemblage received a total metric score of 28, representing 67% comparability to "best attainable" conditions at KB10 (Table A4). Most notable was the reduction in EPT taxa (6). In addition, the abundance of the chironomids *Polypedilum aviceps* and *Parametriocnemus* sp.—which may display low flow adaptations (R. W. Bode, NY DEC, personal communication)—contributed to the low community similarity of KB09 to reference conditions at KB10, where these taxa were not well represented (Table A1). Flow regime and current velocity are important hydrologic determinants of benthic community structure. Flow volume and velocity/depth combinations can have effects on substrate composition and stability, the amount of channel under water, and food availability (Minshall 1984). Current plays a crucial role in the distribution of benthic macroinvertebrates—current velocity affects an organism's ability to gather food, meet respiratory requirements, avoid competition and predation, and colonize or vacate certain habitats (Minshall 1984). Short-term flow fluctuations may modify benthic communities in several ways, most notably by stranding populations in pockets of standing water or on exposed substrates. Some EPT taxa are particularly susceptible to stranding and are relatively intolerant of exposure (Ward 1984). In addition, decreasing discharge and the subsequent elimination of habitat or favorable flow regimes may induce "drift," or the downstream transport by current of benthic animals as a means of escape or dispersal (Wiley and Kohler 1984; Ward 1984). This taxa depletion, either by drift or the periodic loss of riffle habitat, may contribute to reduced EPT richness (score: 0), and subsequent impairment at KB09 (Table A4). In addition, the displacement of these EPT taxa by organisms that may be more tolerant of flow constraints (i.e., *Polypedilum aviceps*, *Parametriocnemus* sp.), contributes to the "slightly impaired" bioassessment. It is unclear whether low flow effects at KB09—if present—are naturally occurring or anthropogenic. It should be mentioned, however, that the entire stretch of Kettle Brook between Kettle Brook Reservoir No. 1 and Waite Pond (located approximately 1.50 miles upstream from the KB09 sampling reach) had dried up during the sampling index period for this watershed survey—possibly the result of flow regulation associated with Kettle Brook Reservoir No. 1.

Fish sampling at KB09 yielded only 4 taxa (Table A6). The reach supported the least diverse assemblage of all the tributary stations, and was dominated by one taxon (*Catostomus commersoni*) considered tolerant of environmental perturbation (Simon 1999). The low species richness and community imbalance at KB09 may be the result of low-flow conditions. Much of the snag, log, and boulder cover that appeared to offer superb fish habitat during spring reconnaissance, was exposed and non-useable during the time of the fish survey. Pools that were deep and interspersed with riffle areas just a few weeks earlier, had become isolated by the time of the August survey.

Despite the resulting "slightly impaired" aquatic community encountered at KB09 during the 1998 survey, conditions appear to have improved considerably since the 1977 biological assessment here. The conspicuous absence of pollution-sensitive forms—especially the EPT taxa—coupled with elevated nutrient levels, indicated a severely stressed aquatic community in 1977 and suggested the presence of one or more toxicants (Johnson et al. 1992). The closing of the Worcester Spinning and Finishing Company and Pioneer Paint and Lacquer—and removal of associated discharges—is probably most directly responsible for improvements to biological integrity in this portion of Kettle Brook.

**KB02**—Kettle Brook, mile point 52.7, downstream from Oxford Street, Worcester, MA

*Habitat*

KB02 began approximately 500 m downstream from the United States Geological Survey (USGS) gaging station at Oxford Street in Worcester, and was located midway between Curtis and Leesville Ponds. The sampling reach meandered through a forested portion of the sub-basin and adjacent to the property of Notre Dame Cemetery. Riffle/run areas were common and mostly comprised of rocky substrates; however, the lack of depth and preponderance of gravel/sand resulted in suboptimal benthos habitat. Fish habitat was slightly better, with overhanging shrubs and instream vegetation providing most of the cover. Both stream banks were well-vegetated and stable. Along the left (west) bank, a wide and undisturbed riparian zone began as alder (*Alnus* sp.), riverbank grape (*Vitis riparia*), and silky dogwood (*Cornus stolinifera*)-dominated shrub growth before grading to a willow (*Salix* sp.) and red maple (*Acer rubrum*)-dominated forest. A similar shrub layer dominated the riparian zone along the right (east) bank, which was reduced due to the close proximity of the cemetery. Herbaceous growth in the form of ferns (*Onoclea sensibilis*) was common throughout the forested understory. Instream vegetation was abundant, covering approximately 75% of the reach and consisting of rooted submergent forms of milfoil (*Myriophyllum* spp.) and starwort (*Callitriche* sp.). Algal growth was fairly minimal and dominated by the filamentous green alga *Stigeoclonium* sp., whose presence may be indicative of organic enrichment (Palmer 1962) (Table A7).

KB02 received a total habitat assessment score of 150/200 (Table A5). Substantial deposits of urban debris were observed throughout the reach and along the right bank. In addition, the dumping of excavated material associated with the cemetery appears to be an historical and current practice. The reduced nature of the riparian buffer between the stream and cemetery magnifies the potential impacts that these activities may have on instream habitat and biological potential.

Benthos

The KB02 macroinvertebrate community received a total metric score of 28, representing 67% comparability to the reference station and indicating a "slightly impaired" assemblage. Benthic community structure and function at KB02 appears to have improved since the 1985 biosurvey, when the assemblage was found to be "moderately impaired" (Johnson et al. 1992). Low richness, reduced EPT values, and a hyperdominance of filter-feeding hydropsychids were the result of an unbalanced community structured in response to organically-enriched conditions during the time of that survey. The community sampled during the 1998 survey was well-represented by feeding groups other than filter-feeders, most notably scrapers such as elmid beetles (Table A1). As with the 1985 assemblage, richness and EPT values remain reduced compared to upstream reference conditions; however, biotic index is actually lower at KB02 than the KB10 reference station. In fact, the KB02 assemblage displayed the lowest biotic index in the entire 1998 survey, further indicating that the effects of organic pollution are not as pronounced in this portion of Kettle Brook as during the 1985 survey. The discrepancy in the community similarity metric value (22%) between KB02 and KB10 is mostly the result of elmid densities, which are high at KB02 but quite low at KB10 (Table A1). The periphyton food resource that supports these scrapers is probably more established at KB02 than at the less productive headwater station KB10. It should be noted that—while not collected—an abundance of filter-feeding sponges and unionid mussels were observed throughout the KB02 sampling reach, indicating that the FPOM food resource remains an important component of trophic status here.

Specific causes of impairment to the KB02 biological community are unknown. The numerous impoundments upstream from the sampling reach probably contribute significant amounts of particulate organic matter, as has been the case historically (Johnson et al. 1992). Nutrient loadings originating

upstream may exacerbate enriched conditions at KB02, and may be responsible for the abundance of instream vegetation here. In addition to impoundment effects, stormwater and various NPS pollution (e.g., road runoff) associated with the highly urbanized portion of this sub-basin probably contribute to the slightly degraded aquatic community at KB02. At the very least, efforts should be made to reduce the amount of dumped material associated with the cemetery property and deposited near or in this portion of Kettle Brook.

**Tatnuck Brook**

From its headwaters in Holden, Tatnuck Brook flows in a southwesterly direction before entering the drinking water supplies of Holden Reservoirs No. 1 and No 2. From here the stream continues in a southerly direction, draining the western portion of the City of Worcester before entering Coes Reservoir. Immediately downstream from this impoundment, Tatnuck Brook merges with Beaver Brook, and then Kettle Brook to form the Middle River. Land use in the Tatnuck Brook sub-basin consists of protected open space in the vicinity of the Holden reservoirs, giving way to heavy commercial and residential development as the stream enters the West Tatnuck/Tatnuck sections of Worcester.

**TB02**—Tatnuck Brook, mile point 1.10, upstream from Williams Millpond, Worcester, MA

*Habitat*

The TB02 sampling reach began immediately upstream from Williams Millpond and ended approximately 300 m downstream from June Street in the residential Tatnuck section of Worcester. Riffle areas, although shallow, contained an abundance of cobble/gravel substrates and offered good epifaunal habitat for macroinvertebrates. Fish habitat (score: 18) was some of the best observed in the 1998 survey, with a variety of woody debris, snags, and overhanging vegetation providing ample cover in the many pools throughout the reach. Not surprising, the fish sample collected at TB02 contained by far the highest densities (n= 302; 7 taxa) of all the tributaries sampled, further supporting the excellent cover available here (Table A6). The left (east) stream bank was well-vegetated and stable, with a red maple (*Acer rubrum*) and white ash (*Fraxinus americana*)-dominated riparian zone extending undisturbed from the channel. Herbaceous growth was common as well, especially purple loosestrife (*Lythrum salicaria*) and ferns (*Onoclea* sp.). The right (west) bank, though well-vegetated, was less stable due to its steep nature. Again, mixed hardwood trees dominated the riparian zone, with occasional shrubby forms of elderberry (*Sambucus canadensis*), alder (*Alnus* sp.), riverbank grape (*Vitis riparia*) and slippery elm (*Alnus rubra*) present as well. Instream vegetation consisted mainly of mosses. Filamentous forms of the green alga *Spirogyra* sp. and the diatoms *Melosira* sp. and *Synedra* sp.—considered indicators of organic enrichment (Palmer 1962)—were observed, yet minimal (Table A7).

TB02 received a total habitat assessment score of 161/200 (Table A5). While this was a fairly high score relative to other biomonitoring stations, obvious NPS pollution threatens habitat and biological integrity here. The dumping of yard waste (grass clippings, leaves) and trash, especially from the nearby residences along the right bank, appears to be a common practice in this portion of Tatnuck Brook.

*Benthos*

The TB02 benthos assemblage received a total metric score of 28, representing 67% comparability to the Kettle Brook reference station. While a biotic index comparable to reference conditions suggests the absence of serious organic pollution, a low score for EPT index (score: 0) may indicate some degree of community stress and contributed most to the "slightly impaired" designation for biological condition at TB02 (Table A4).

Localized NPS pollution—most notably the dumping of yard waste—may pose the greatest threat to biological integrity at TB02. Instream effects from dumping may be exacerbated by the steepness of the bank and the somewhat reduced riparian buffer along the right bank. Indeed, substantial deposits of fine organic matter coated most substrates in the sampling reach—possibly the result of organic loadings related to dumping activities. Impoundments just upstream from the reach may also contribute to the presence of organic particulates at TB02 and their resulting effects (e.g., reduced EPT index) on the benthic community.

Outreach efforts should be made to curb the dumping of trash and yard waste in this portion of Tatnuck Brook, and to educate residents of the ecological implication of this type of NPS pollution. Several residential properties abut the stream in areas where the riparian vegetative buffer is reduced, especially the stretch between Patch Reservoir and Williams Millpond in the West Tatnuck/Tatnuck sections of Worcester.

***Dark Brook***

From its source water in Eddy Pond, Dark Brook flows in a northerly direction, draining a heavily developed portion of the sub-basin that includes the town of Auburn. Immediately downstream from Interstate 90 and the Auburn Mall, Dark Brook receives considerable discharge from Ramshorn Brook and continues to flow north for approximately a mile before merging with Kettle Brook. The Ramshorn Brook sub-basin, which originates in Ramshorn Pond, is considerably less developed than Dark Brook and flows through numerous impoundments as it flows in a northwesterly direction towards its confluence with Dark Brook in Auburn.

**RB01**—Dark Brook, mile point 0.80, downstream from Route 12, Auburn, MA

*Habitat*

The RB01 sampling reach, which appeared to have been historically channelized, began approximately 150 m downstream from Route 12 and just downstream from a small footbridge. Land use in this portion of the stream was dominated by the recreational fields of Auburn High School along the left (west) bank, commercial development and associated parking lots along the right (east) bank, and the vast expanse of the Auburn Mall and surrounding parking lots just upstream from the sampling reach. In addition, a small unnamed impoundment—possibly created as a stormwater retention basin—just upstream from RB01 and immediately downstream from the mall receives heavy stormwater runoff directly from the mall parking lot and indirectly from downtown Auburn, which is just upstream from the mall. Based on visual observations during the time of the biosurvey, this impoundment appeared highly productive in terms of algal growth and aquatic vegetative cover.

Rocky (mostly gravel and cobble) riffle areas, though shallow, dominated the sampling reach at RB01 and offered excellent epifaunal habitat for macroinvertebrates. Fish cover was only marginal, however, due to shallow water depth and lack of stable habitat save for occasional large rubble. Despite the shallow nature of this portion of the stream, water appeared to reach the base of both banks, leaving only a minimal amount of channel substrate exposed. The moderately stable right (east) bank was fairly well-vegetated, while erosional areas and closely cropped vegetation (i.e., mowed lawn) led to further habitat score reductions for stability and bank vegetation along the left (west) bank. Riparian vegetation was extremely reduced along both banks, consisting of occasional pines and red maples (*Acer rubrum*) and a thin shrub layer of elderberry (*Sambucus canadensis*) and sweet pepperbush (*Clethra alniflora*) giving way to an expanse of lawn along the left bank and a parking lot near the right bank. Instream algae and aquatic vegetation was virtually absent in the sampling reach; however, fragments of *Myriophyllum* sp. and *Cabomba* sp.—presumably originating from the impoundment just upstream—were observed.

Potential NPS inputs are numerous, but are primarily related to runoff from adjacent parking lots, playing fields, and road crossings, and are probably exacerbated by the narrow riparian buffer afforded to this portion of the stream. RB01 received a total habitat assessment score of 127/200—one of the lowest evaluations received by a station during the 1998 biomonitoring survey (Table A5). Despite the vast areas of impervious surfaces immediately upstream from the sampling reach, sediment deposition was minimal at RB01. Sand runoff from the expansive mall parking probably "settles out" in the adjacent unnamed impoundment/stormwater retention basin before reaching the stream system.

*Benthos*

The RB01 assemblage received a total metric score of 18, representing 43% comparability to the reference station at KB10 and resulting in "moderately impaired" biological status (Table A4). The dominance of the community by relatively few taxa, particularly the filter-feeding caddisflies (filter-feeding sponges were extremely abundant as well, but not included in the sample) Hydropsychidae and

Philopotamidae indicates an unbalanced community responding to an overabundance of fine particulate organic matter in the water column. That the assemblage is dominated by filter-feeders is not surprising, as upstream impoundments are no doubt a contributing source of suspended FPOM; however, the high densities represented by these taxa are somewhat disconcerting and indicative of effects from excessive enrichment. Typically, in lentic systems such as the impoundments upstream, the primary source of organic matter is autochthonous (produced within the system), with secondary inputs of allochthonous (transported into the system from someplace else) materials from shoreline vegetation and fluvial inputs (Wetzel 1975, Merritt et al. 1984). Phytoplankton production—and to a lesser extent, littoral vascular plant production—and associated dissolved organic matter (DOM), are the primary source of autochthonous matter (Wetzel 1975). It is the physical-chemical flocculation (nonbiological) of this DOM and/or other biological processes that leads to the formation of FPOM, the primary nutrition resource utilized by filter-feeders (Wetzel 1975). While FPOM production in lotic systems is primarily a result of the processing of Course Particulate Organic Material (CPOM) contributed by aquatic shredders, the high concentration of FPOM in stream systems immediately below pond and reservoir outlets has mainly lentic origins. If these lentic systems are subjected to increasingly eutrophic conditions the resulting effects of enrichment (i.e., increased algal, plant, and DOM production) can be seen not only in the lentic fauna, but also the lotic aquatic communities immediately downstream.

The enrichment effects (e.g., dominance of filter-feeders, reduced EPT index) reflected in the RB01 benthic community are probably most directly related to the eutrophic nature of the unnamed impoundment immediately upstream (or some of the other larger impoundments farther upstream). Nutrient/organic loadings originating from urban runoff here or farther upstream in the vicinity of Auburn probably contribute to the productive conditions that supply an abundant FPOM food resource to the downstream aquatic community.

Fish sampling at RB01 resulted in the collection of 7 different species (Table A6). Three of these taxa were considered "pond species," further corroborating the influence that the upstream impoundment has on aquatic community structure in this portion of Dark Brook.

## SUMMARY & RECOMMENDATIONS

*Mainstem (Blackstone River and Middle River)*—Though perhaps not at the gross level observed during previous bioassessments in this watershed, the effects of organic enrichment were reflected in all the mainstem benthos communities sampled during the 1998 biosurveys. In most cases, point source discharges were probably most responsible for organic pollutant loading to this portion of the river; however, other stressors associated with urban runoff also probably contribute to water quality degradation. In addition, toxic impacts may exist in the mainstem Blackstone River, particularly in the upper portion of the watershed. Biological monitoring is recommended at all 1998 mainstem biomonitoring stations during the next "year 2" phase of the "basin cycle" for this watershed.

**BLK00A**—Despite the moderately impaired aquatic community observed here during the 1998 biosurvey, biological conditions have probably improved since the previous DEP survey conducted in 1985. Organic enrichment—probably the result of stormwater or other types of urban runoff—appears to shape community structure in this portion of the river; however, the toxic effects suspected during the 1985 biosurvey probably no longer exist. An investigation into the origins (e.g., upstream road crossings, adjacent parking lots) of substantial instream sediment deposition here is recommended, as sedimentation poses a major threat to biological integrity in this portion of the river.

**BLK01**—Organic pollutant loadings entering this portion of the Blackstone River from Mill Brook continue to compromise water quality and biological integrity at BLK01. In addition, the conspicuous absence of filter-feeders and the extremely low abundance of invertebrates suggests the presence of a toxicant (i.e., ammonia and/or metals toxicity). Again, Mill Brook—and especially the Worcester CSO facility—probably is the source of potential toxic stressors. Instream toxicity testing, as well as toxicity analyses of the CSO discharge, should be conducted to confirm this. Sediment toxicity at BLK01 is recommended as well.

**BLK02**—As has historically been the case, the severely impaired benthic community here is structured in respose to severe organic enrichment and possible toxicants, and is probably most impacted by the UBWPAD discharge. A review of this facility's permit limits and current Discharge Monitoring Report

(DMR) data is recommended. Additional water quality monitoring, especially toxicity testing to investigate potential effects of heavy metals, chlorine, and ammonia-nitrogen, is recommended both instream and in the UBWPAD effluent. Significant deposits of sand compromise biological integrity at BLK01 as well, and probably originate from recent highway construction activities (i.e., new exit and ramp construction) just upstream from the sampling reach. An investigation into the efficacy of pre-existing nonpoint source pollution-related Best Management Practices (BMPs), or the implementation of new BMPs, associated with the highway interchange project is recommended.

**BLK07** and **BLK12A**—Biological conditions have probably improved at these stations since the 1991 biosurvey. Nevertheless, the benthos assemblages present displayed a moderate degree of impairment. Nutrient loading and organic enrichment—probably the result of point source discharges upstream—strongly influence aquatic community structure and compromise water quality in this portion of the Blackstone River. A review of NPDES permits and DMR data for wastewater treatment facilities in Millbury, Grafton, Uxbridge, and Northbridge may be warranted.

*Tributaries*—Biological integrity appeared better at most monitored tributary stations than mainstem stations, probably due to the lack of point source discharges. At least some degree of nonpoint source pollution was evident at most tributaries sampled, often compromising biological potential and/or habitat quality. In some cases, remediation efforts may simply be a matter of stream clean-ups, BMP implementation, or outreach efforts, while in other cases more complex land use issues will need to be addressed if biological integrity is to be improved. If feasible, biological monitoring is recommended at all 1998 tributary biomonitoring stations during the next "year 2" phase of the "basin cycle" for this watershed.

**BLK09-8A**—Though pristine or near-pristine biological conditions and water quality no longer exist in the Blackstone River watershed, the BLK09-8A station in the Mumford River represents the "best attainable" (i.e., "least disturbed") conditions for the basin at this time. The optimum benthic community structure and balanced trophic structure observed at BLK09-8A warrant its reference station status. NPS pollution here was observed, however, and poses a threat to habitat and biological potential. Sediment deposition—possibly the result of the upstream road crossing (Manchaug Street) compromises habitat quality by reducing productive epifaunal microhabitat. A site investigation should be conducted to determine if BMPs might address sediment inputs to this portion of the river. In addition, the dumping of grass clippings, leaves, and excavated materials—presumably associated with the adjacent cemetery—occurs along the right bank of the sampling reach and should be strongly discouraged.

**KB10, KB09,** and **KB02**—The reference quality conditions for habitat quality and biological integrity observed near the headwaters of this stream (KB09) become diminished as one moves farther downstream into more urbanized portions of the sub-basin. Dramatic improvements in benthic communtiy structure were observed at KB09 since previous surveys; however, biological impairment was still evident during the 1998 survey. Despite the high habitat evaluation at KB09, occasional reductions in flow—either naturally occurring or the result of upstream reservoir draw-downs—may limit biological potential here. In addition, considerable deposits of trash may warrant a stream clean-up effort in this portion of Kettle Brook. Impoundment effects and moderate levels of organic enrichment continue to shape the aquatic community at KB02, though probably not to the extent observed in previous surveys. At the very least, efforts should be made to reduce the amount of dumped material associated with the adjacent cemetery property and deposited near/in this portion of Kettle Brook.

**TB02**—Outreach efforts should be made to curb the dumping of trash and yard waste in this portion of Tatnuck Brook, and to educate residents of the ecological implication of this type of NPS pollution. Several residential properties abut the stream in areas where the riparian vegetative buffer is reduced, especially the stretch between Patch Reservoir and Williams Millpond in the West Tatnuck/Tatnuck sections of Worcester. In addition, channel modifications created immediately upstream from the sampling reach have resulted in a small impounded area that apparently has become a gathering area for ducks. The feeding of these waterfowl (which appears to be a current practice) should be discouraged, as resulting nutrient loadings may impact downstream water quality and biological conditions.

**RB01**—Complex land use issues in this portion of the sub-basin make it difficult to target specific sources of impairment to the RB01 aquatic community. A review of stormwater management practices in the surrounding area—especially those associated with parking lot runoff from the Auburn Mall—is suggested.

Habitat improvements in the RB01 sampling reach—particularly restoration of riparian vegetation—may help to reduce/buffer NPS inputs into this portion of the stream and improve overall aesthetics.

**WR01** and **BLK15-1**—Habitat and biological integrity were good at both these tributary stations regardless of which reference station was used. Biological conditions at BLK15-1 have shown marked improvements, especially in terms of trophic and community structure, compared to previous biological surveys. The "slight impairment" received by the WR01 benthos when compared to BLK09-8A was probably more a function of habitat and hydrologic differences rather than actual impairment—WR01 should be given "full support" status for the aquatic life use assessment required by Section 305b of the Clean Water Act. NPS pollution inputs were minimal at both stations. Possible sources of instream sedimentation at BLK15-1 may be the erosional activity of naturally-sandy flood plain soils in the sub-basin, or NPS inputs (e.g., from the upstream road crossing). Certainly, numerous sand and gravel operations adjacent to the river are potential NPS stressors, and their activities may warrant further investigation (i.e., site visits). Improvements to the stream's riparian zone (e.g., vegetative restoration) in the small park just upstream from BLK15-1 and the Summer Street crossing may help reduce NPS inputs in this area.

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**APPENDIX**
Benthos (macroinvertebrate and periphyton) and fish taxa lists, RBP III analyses, and Habitat evaluations

**Table A1.** Species-level taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites in the Blackstone River watershed between 9 and 16 July 1998. Sampling stations were in: Middle River (BLK00A); Blackstone River (BLK01; BLK02; BLK07; BLK12A); Kettle Brook (KB02; KB09; KB10); Tatnuck Brook (TB02); Dark Brook (RB01); Mumford River (BLK09-8A); West River (WR01); and Mill River (BLK15-1). The macroinvertebrate collection procedure utilized kick sampling.

| TAXON | FFG[1] | TV[2] | BLK00A | BLK01 | BLK02 | BLK07 | BLK12A | BLK09-8A | KB09 | KB10 | KB02 | TB02 | RB01 | WR01 | BLK15-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Physidae | GC | 8 | | | 1 | | | | | | | | | | |
| *Ferrissia* sp. | SC | 7 | 3 | | | | | | | | | | | | |
| Pisidiidae | FC | 6 | 17 | | | 2 | 1 | 1 | | | 4 | 3 | 5 | 4 | |
| Lumbricina | GC | 8 | 5 | | 1 | | | | | 1 | | | | | |
| Enchytraeidae | GC | 10 | | 22 | 7 | 1 | | | 1 | 1 | | | | | |
| Tubificidae (w/o capilliform chaetae) | GC | 10 | 1 | 31 | 33 | 24 | | | | | | | | | |
| Naididae | GC | 10 | 1 | | | | | | | | | | | | |
| *Dero* sp. | GC | 10 | | | | | | | 1 | | | | | | |
| *Nais* sp. | GC | 9 | | | | | | | | | | | | | |
| *Nais alpina* | GC | 9 | | | | | | 1 | | | | | | 2 | |
| *Nais behningi* | GC | 6 | | | | | | | 1 | | | | | 20 | |
| *Nais communis* | GC | 8 | | 2 | | | | | | | | | | | |
| *Nais elinguis* | GC | 10 | | 1 | 2 | | | | | | | | | | |
| *Nais variabilis* | GC | 10 | | 5 | | 5 | | | | | | | | | |
| *Pristina aequiseta* | GC | 8 | | 2 | | | | | | | | | | | |
| *Eclipidrilus* sp. | GC | 8 | 7 | | | | | | | 2 | 1 | 1 | | | |
| *Lumbriculus* sp. | GC | 8 | | | | | 4 | 8 | 9 | | 1 | | 6 | | 3 |
| Erpobdellidae | PR | 8 | | 1 | 1 | 2 | | | | | | | | | |
| *Caecidotea communis* | GC | 8 | 1 | 1 | | 1 | | | | | | 1 | 1 | | |
| *Crangonyx* sp. | GC | 8 | 2 | | | 1 | | | | | | | 2 | 1 | |
| *Hyalella azteca* | GC | 8 | | | | | | | | | | | | 1 | |
| Hydracarina | PR | 6 | 14 | 2 | | 1 | 4 | 1 | | | | | | 2 | |
| Baetidae | GC | 4 | | | | | | 2 | 3 | 3 | 3 | | 1 | | |
| *Acentrella* sp. | SC | 4 | | | | | 1 | | | | | | | | |
| *Baetis* sp. | GC | 6 | | | | | | | 7 | | | | | | 5 |
| *Baetis* sp. 1 (2-tailed) | GC | 6 | | | | | | 4 | | 2 | 5 | | | | |
| *Baetis* sp. 2 (short terminal filament) | GC | 6 | | | | | | | | | | | | | |
| *Baetis* sp. 3 (3-tailed) | GC | 6 | | | | | | 7 | | 5 | 3 | 1 | | 1 | |
| *Isonychia* sp. | GC | 4 | | | | | | 4 | | | | | | 4 | |
| Heptageniidae | SC | 4 | | | | | | | | | | 1 | 1 | | 1 |
| *Epeorus* sp. | SC | 1 | | | | | | | | 1 | | | | | |
| *Stenonema* sp. | SC | 3 | | | | | 6 | 5 | | 2 | 13 | 12 | | 9 | |
| *Boyeria* sp. | PR | 2 | | | | | | | | | 1 | | | | |

[1] Functional Feeding Group (FFG) lists the primary feeding habit of each species and follows the abbreviations:
FC-Filtering Collector, GC-Gathering Collector, PR-Predator, SC-Scraper; SH-Shredder.
[2] Tolerance Value (TV) is an assigned value used in the calculation of the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.

**Table A1** continued.

| TAXON | FFG[1] | TV[2] | BLK00A | BLK01 | BLK02 | BLK07 | BLK12A | BLK09-8A | KB09 | KB10 | KB02 | TB02 | RB01 | WR01 | BLK15-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Leuctridae | SH | 0 | | | | | | 1 | | | | | | | |
| *Leuctra* sp. | SH | 1 | | | | | | | | 1 | | | | | |
| *Acroneuria* sp. | PR | 0 | | | | | | | | 1 | | | . | | |
| *Paragnetina* sp. | PR | 1 | | | | | | | | 1 | | | | 5 | |
| *Nigronia* sp. | PR | 6 | | | | | | 1 | 2 | | | | | 1 | 2 |
| *Chimarra* sp. | FC | 3 | | | | | . | | 5 | 8 | 21 | 21 | 8 | 6 | 1 |
| *Dolophilodes* sp. | FC | 1 | | | | | | | 2 | | | | | 1 | |
| Hydropsychidae | FC | 4 | | | | 10 | 6 | | | | | | | | |
| *Cheumatopsyche* sp. | FC | 7 | | | 1 | 6 | 5 | 2 | 3 | 6 | 2 | 24 | 10 | 4 | 3 |
| *Hydropsyche* sp. | FC | 4 | 6 | | | | 1 | | 3 | | | | | | |
| *Hydropsyche betteni* gr. | FC | 8 | 28 | | 3 | 8 | 43 | | | | 5 | 4 | 51 | 23 | 9 |
| *Hydropsyche morosa* gr. | FC | 6 | | | | | | 16 | | 4 | | | | | 7 |
| *Macrostemum* sp. | FC | 4 | | | | | | | | | | | | | 1 |
| *Rhyacophila fuscula* gr. | PR | 2 | | | | | | | 10 | | | | | | |
| *Glossosoma* sp. | SC | 2 | | | | | | | | | | | | 1 | 3 |
| *Brachycentrus* sp. | FC | 2 | | | | | 1 | | | | | | | 1 | |
| *Micrasema* sp. | SH | 2 | | | | | | 3 | | | | | | | |
| *Apatania* sp. | SC | 1 | | | | | | | | | | | | | 8 |
| *Pycnopsyche* sp. | SH | 2 | | | | | | | | | 1 | | | | 1 |
| *Neophylax* sp. | SC | 2 | | | | | | | | | | | | | 1 |
| *Dineutus* sp. | PR | 6 | | | | | | | | | 1 | | | | |
| *Psephenus herricki* | SC | 3 | | | | | | | | | 3 | | | | 6 |
| Elmidae | SC | 4 | | | | | | | | | 2 | | | | |
| *Optioservus* sp. | SC | 3 | | | | | | | | | | | | | 26 |
| *Oulimnius latiusculus* | SC | 2 | | | | | | 1 | | | 23 | | | 2 | 5 |
| *Promoresia tardella* | SC | 0 | | | | | | 18 | | 2 | | | | | 1 |
| *Stenelmis* sp. | SC | 5 | 1 | | | | | 1 | | | 9 | 10 | 9 | | 5 |
| *Georyssus* sp. | GC | 4 | | | | | | | | 1 | | | | | |
| *Antocha* sp. | GC | 5 | | | | | | 6 | 1 | | | | | | 1 |
| *Tipula* sp. | SH | 8 | | | | | | | 1 | | | | | | |
| *Simulium* sp. | FC | 4 | | | 14 | | 2 | 6 | 2 | 5 | | 9 | 11 | 3 | 1 |
| Chironomidae | GC | 6 | | | | 2 | 1 | | | 2 | | | | | |
| Tanypodinae | PR | 7 | | | | 1 | | | | | | | | | |
| *Conchapelopia* sp. | PR | 9 | | 1 | 2 | | . | | 8 | | | 3 | | 1 | 1 |
| *Meropelopia* sp. | PR | 7 | | | 1 | | | | | | | | | | |
| *Pentaneura* sp. | PR | 5 | | | | | | | | | 1 | | | | |
| *Thienemannimyia* gr. | PR | 6 | | 1 | | 2 | | | | | | | | | |
| *Thienemannimyia* sp. | PR | 6 | | | | | | | | | | 1 | | | |
| Diamesinae | GC | 2 | 1 | | | | | | | | | | | | |

[1] Functional Feeding Group (FFG) lists the primary feeding habit of each species and follows the abbreviations:
FC-Filtering Collector, GC-Gathering Collector, PR-Predator, SC-Scraper; SH-Shredder.

[2] Tolerance Value (TV) is an assigned value used in the calculation of the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.

**Table A1** continued.

| TAXON | FFG[1] | TV[2] | BLK00A | BLK01 | BLK02 | BLK07 | BLK12A | BLK09-8A | KB09 | KB10 | KB02 | TB02 | RB01 | WR01 | BLK15-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Diamesa* sp. | GC | 8 | | | | | | | 3 | | | 2 | | | 2 |
| *Potthastia longimanus* gr. | GC | 7 | | | | | | 1 | | | | | 1 | | |
| Orthocladiinae | GC | 5 | | 1 | | 1 | 2 | | 2 | | | | | | |
| *Cardiocladius* sp. | PR | 6 | 1 | 8 | 7 | 3 | 8 | 1 | | | | | 1 | | |
| *Cricotopus* sp. | SH | 7 | | | 5 | 3 | | 1 | | | | | | | |
| *Cricotopus/Orthocladius* sp. | GC | 7 | | | | 7 | 2 | | | | | | 1 | | |
| *Cricotopus bicinctus* | GC | 7 | | | 20 | 4 | | | | | | | | | |
| *Cricotopus tremulus* gr. | SH | 7 | | 2 | 1 | 2 | | 1 | | | | | | | |
| *Cricotopus vierriensis* | SH | 7 | | | | | | | | 1 | | | | | |
| *Eukiefferiella* sp. | GC | 6 | | | | | 1 | | | | | | | | |
| *Orthocladius* sp. | GC | 6 | 2 | 10 | | | 1 | | | | | | | | |
| *Parachaetocladius* sp. | GC | 0 | | | | | | 4 | | | | | | | |
| *Parametriocnemus* sp. | GC | 4 | | | | | | 1 | 17 | 8 | | 5 | | 2 | |
| *Paraphaenocladius* sp. | GC | 4 | | | | | | | | | | 1 | | | |
| *Synorthocladius* sp. | GC | 5 | | | | 2 | | | | | | | | | |
| *Thienemanniella* sp. | GC | 6 | | | | 1 | | 1 | | | | | | | |
| *Tvetenia bavarica* gr. | GC | 5 | | | | 1 | | | | 2 | | | | 1 | |
| *Tvetenia vitracies* gr. | GC | 5 | | | | 1 | 10 | 2 | 1 | 10 | | | | 6 | 1 |
| Chironominae | GC | 6 | | | | | 1 | | | | | | | | |
| *Glyptotendipes* sp. | SH | 9 | | 1 | | | | | | | | | | | |
| *Microtendipes* sp. | FC | 6 | | | | | | | | | | | | 1 | |
| *Microtendipes pedellus* gr. | FC | 6 | | | | | | | | 1 | | | | | |
| *Phaenopsectra* sp. | SC | 7 | | | | | | | 1 | | | | | | |
| *Polypedilum* sp. | SH | 6 | 1 | | | 1 | | | 1 | 1 | | | | | |
| *Polypedilum aviceps* | SH | 4 | | | | | | 1 | 13 | 8 | | | | 1 | |
| *Polypedilum convictum* | SH | 5 | | | | | 4 | | 5 | 16 | 1 | 5 | | 3 | |
| *Polypedilum fallax* gr. | SH | 6 | | | 1 | | | | | | | | | | |
| *Polypedilum laetum* | SH | 6 | | | | 3 | | | | | | | | | |
| *Polypedilum scalaenum* gr. | SH | 9 | | 1 | 1 | 11 | | | | | | | | | |
| *Polypedilum simulans/digitifer* | SH | 6 | | | 2 | | | | | | | | | | |
| *Stenochironomus* sp. | GC | 6 | | | | | | | | | | | | | 1 |
| *Micropsectra* sp. | GC | 1 | | | | | | 6 | | 1 | | | | 3 | |
| *Rheotanytarsus* sp. | FC | 6 | | | | | | | 1 | | | | | | |
| *Rheotanytarsus distinctissimus* gr. | FC | 6 | | | | | | | 1 | | | | | | |
| *Rheotanytarsus exiguus* gr. | FC | 6 | | | | | 1 | 1 | 4 | | 2 | | | 1 | 1 |
| *Tanytarsus* sp. | FC | 7 | | | | 1 | | | | 1 | | 1 | | | |
| *Zavrelia* sp. | FC | 3 | | | | | | | 1 | | | | | | |
| *Chelifera* sp. | PR | 6 | | | | 1 | | | 1 | 2 | | | | | |
| *Hemerodromia* sp. | PR | 6 | 2 | 2 | 1 | | | | | 1 | | | 4 | | 1 |
| **TOTAL** | | | **93** | **94** | **104** | **108** | **105** | **108** | **110** | **100** | **102** | **105** | **112** | **110** | 97 |

[1] Functional Feeding Group (FFG) lists the primary feeding habit of each species and follows the abbreviations:
FC-Filtering Collector, GC-Gathering Collector, PR-Predator, SC-Scraper; SH-Shredder.

[2] Tolerance Value (TV) is an assigned value used in the calculation of the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.

**Table A2.** Summary of RBP III data analysis for macroinvertebrate communities sampled at stations in the Blackstone River watershed between 9 and 16 July 1998. Seven biological metrics were calculated and scored (in *italics*) for taxa collected at each station. Scores were then totaled and compared to the regional reference station (BLK09-8A). The percent comparability to the reference station yields a final impairment score for each study site.

| STATION # | **BLK09-8A** | | **BLK00A** | | **BLK01** | | **BLK02** | | **BLK07** | | **BLK12A** | | **WR01** | | **BLK15-1** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Mumford River | | Middle River | | Blackstone River | | Blackstone River | | Blackstone River | | Blackstone River | | West River | | Mill River | |
| Habitat Score | 162 | | 143 | | 142 | | 137 | | 123 | | 167 | | 172 | | 168 | |
| Taxa Richness | 28 | *6* | 16 | *2* | 17 | *4* | 18 | *4* | 23 | *6* | 15 | *2* | 28 | *6* | 26 | *6* |
| Biotic Index | 4.04 | *6* | 6.86 | *2* | 8.74 | *0* | 7.82 | *2* | 7.63 | *2* | 6.41 | *2* | 5.34 | *4* | 4.31 | *6* |
| Ept Index | 8 | *6* | 1 | *0* | 0 | *0* | 2 | *0* | 2 | *0* | 5 | *0* | 10 | *6* | 11 | *6* |
| Ept/Chironomidae | 2.20 | *6* | 6.80 | *6* | 0.00 | *0* | 0.10 | *0* | 0.52 | *0* | 2.03 | *6* | 2.89 | *6* | 6.67 | *6* |
| Scrapers/Filterers | 0.96 | *6* | 0.08 | *0* | 0.00 | *0* | 0.00 | *0* | 0.00 | *0* | 0.12 | *0* | 0.27 | *2* | 2.43 | *6* |
| % Dominant Taxon | 17% | *6* | 30% | *4* | 33% | *2* | 32% | *2* | 22% | *4* | 41% | *0* | 21% | *4* | 27% | *4* |
| Community Similarity | 100% | *6* | 4% | *0* | 3% | *0* | 9% | *0* | 8% | *0* | 18% | *0* | 25% | *0* | 21% | *0* |
| Total Metric Score | | *42* | | *14* | | *6* | | *8* | | *12* | | *10* | | *28* | | *34* |
| % Comparability To Reference Station | | | 33% | | 14% | | 19% | | 29% | | 24% | | 67% | | 81% | |
| Biological Condition-Degree Of Impairment | REFERENCE | | MODERATELY IMPAIRED | | SEVERELY IMPAIRED | | SEVERELY IMPAIRED | | MODERATELY IMPAIRED | | MODERATELY IMPAIRED | | SLIGHTLY IMPAIRED | | NON-IMPAIRED | |

**Table A3.** Summary of RBP III data analysis for macroinvertebrate communities sampled in the Blackstone River watershed between 9 and 16 July 1998. Seven biological metrics were calculated and scored (in *italics*) for taxa collected at each study station (BLK01; BLK02). Scores were then totaled and compared to the upstream reference station (BLK00A and BLK01 respectively). The percent comparability to the reference station yields a final impairment score.

| STATION # | **BLK00A** | | **BLK01** | | **BLK01** | | **BLK02** | |
|---|---|---|---|---|---|---|---|---|
| Stream | Middle River | | Blackstone River | | Blackstone River | | Blackstone River | |
| Habitat Score | 143 | | 142 | | 142 | | 137 | |
| Taxa Richness | 16 | *6* | 17 | *6* | 17 | *6* | 18 | *6* |
| Biotic Index | 6.86 | *6* | 8.74 | *4* | 8.74 | *6* | 7.82 | *6* |
| Ept Index | 1 | *6* | 0 | *0* | 0 | *6* | 2 | *6* |
| Ept/Chironomidae | 6.80 | *6* | 0.00 | *0* | 0.00 | *6* | 0.10 | *6* |
| Scrapers/Filterers | 0.08 | *6* | 0.00 | *0* | 0.00 | *6* | 0.00 | *6* |
| % Dominant Taxon | 30% | *4* | 33% | *2* | 33% | *2* | 32% | *2* |
| Community Similarity | 100% | *6* | 10% | *0* | 100% | *6* | 53% | *4* |
| Total Metric Score | | *40* | | *12* | | *38* | | *36* |
| % Comparability To Reference Station | | | 30% | | | | 95% | |
| Biological Condition-Degree Of Impairment | **REFERENCE** | | **MODERATELY IMPAIRED** | | **REFERENCE** | | **NON-IMPAIRED** | |

**Table A4.** Summary of RBP III data analysis for macroinvertebrate communities sampled at tributary stations in the Blackstone River watershed between 9 and 16 July 1998. Seven biological metrics were calculated and scored (in *italics*) for taxa collected at each station. Scores were then totaled and compared to the regional reference station (KB10). The percent comparability to the reference station yields a final impairment score for each study site.

| STATION # | **KB10** | | **KB09** | | **KB02** | | **TB02** | | **RB01** | | **WR01** | | **BLK15-1** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream | Kettle Brook | | Kettle Brook | | Kettle Brook | | Tatnuck Brook | | Dark Brook | | West River | | Mill River | |
| Habitat Score | 179 | | 162 | | 150 | | 161 | | 127 | | 172 | | 168 | |
| Taxa Richness | 27 | *6* | 25 | *6* | 18 | *4* | 18 | *4* | 15 | *2* | 28 | *6* | 26 | *6* |
| Biotic Index | 4.72 | *6* | 5.17 | *6* | 3.88 | *6* | 5.08 | *6* | 6.65 | *4* | 5.34 | *6* | 4.31 | *6* |
| Ept Index | 10 | *6* | 6 | *0* | 7 | *2* | 6 | *0* | 5 | *0* | 10 | *6* | 11 | *6* |
| Ept/Chironomidae | 0.67 | *6* | 0.57 | *6* | 13.25 | *6* | 3.50 | *6* | 23.67 | *6* | 2.89 | *6* | 6.67 | *6* |
| Scrapers/Filterers | 0.20 | *6* | 0.05 | *2* | 1.47 | *6* | 0.37 | *6* | 0.12 | *6* | 0.27 | *6* | 2.43 | *6* |
| % Dominant Taxon | 16% | *6* | 15% | *6* | 23% | *4* | 23% | *4* | 46% | *0* | 21% | *4* | 27% | *4* |
| Community Similarity | 100% | *6* | 36% | *2* | 22% | *0* | 33% | *2* | 20% | *0* | 29% | *0* | 12% | *0* |
| Total Metric Score | | *42* | | *28* | | *28* | | *28* | | *18* | | *34* | | *34* |
| % Comparability To Reference Station | | | 67% | | 67% | | 67% | | 43% | | 81% | | 81% | |
| Biological Condition-Degree Impairment | REFERENCE | | SLIGHTLY IMPAIRED | | SLIGHTLY IMPAIRED | | SLIGHTLY IMPAIRED | | MODERATELY IMPAIRED | | NON-IMPAIRED | | NON-IMPAIRED | |

**Table A5.** Habitat assessment summary for macroinvertebrate biomonitoring stations sampled during the 1998 Blackstone River watershed survey. For those primary parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For those secondary parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor.

| STATION | BLK00A | BLK01 | BLK02 | BLK07 | BLK12A | BLK09-8A | KB09 | KB10 | KB02 | TB02 | RB01 | WR01 | BLK15-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Primary Parameters (Range is 0-20)** | | | | | | | | | | | | | |
| Instream Cover | 14 | 12 | 10 | 8 | 18 | 16 | 17 | 15 | 13 | 18 | 9 | 17 | 17 |
| Epifaunal Substrate | 17 | 17 | 14 | 18 | 17 | 18 | 19 | 19 | 12 | 17 | 18 | 19 | 16 |
| Embeddedness | 13 | 14 | 11 | 12 | 13 | 16 | 19 | 20 | 16 | 16 | 13 | 19 | 12 |
| Channel Alteration | 16 | 12 | 13 | 5 | 18 | 19 | 19 | 20 | 18 | 16 | 12 | 18 | 20 |
| Sediment Deposition | 7 | 12 | 9 | 6 | 14 | 12 | 14 | 20 | 15 | 16 | 16 | 18 | 11 |
| Velocity-Depth Combinations | 18 | 16 | 17 | 18 | 18 | 17 | 15 | 10 | 10 | 12 | 12 | 19 | 15 |
| Channel Flow Status | 16 | 17 | 17 | 19 | 19 | 19 | 10 | 18 | 15 | 15 | 16 | 19 | 19 |
| **Secondary Parameters (Range is 0-10 for each bank) (Left/Right)** | | | | | | | | | | | | | |
| Bank Vegetative Protection | 9/9 | 9/9 | 8/7 | 7/8 | 10/8 | 10/9 | 9/9 | 10/10 | 9/8 | 10/8 | 6/8 | 5/10 | 10/10 |
| Bank Stability | 7/8 | 8/10 | 10/8 | 10/9 | 6/9 | 10/7 | 6/6 | 9/9 | 10/9 | 10/6 | 6/8 | 2/10 | 10/10 |
| Riparian Vegetative Zone Width | 1/8 | 3/3 | 6/7 | 1/2 | 10/7 | 8/1 | 10/9 | 10/9 | 10/5 | 9/8 | 1/2 | 6/10 | 8/10 |
| **TOTAL SCORE** | **143** | **142** | **137** | **123** | **167** | **162** | **162** | **179** | **150** | **161** | **127** | **172** | **168** |

**Table A6.** Fish population and density data collected by DWM at 6 biomonitoring stations in the Blackstone River watershed between 4 and 5 August 1998. Sampling stations were at: West River (WR01), Mill River (BLK15-1), Tatnuck Brook (TB02), Dark Brook (RB01), Kettle Brook (KB09), and Mumford River (BLK09-8A).

| TAXON | WR01 | BLK15-1 | TB02 | RB01 | KB09 | BLK09-8A |
|---|---|---|---|---|---|---|
| **Salmonidae** | | | | | | |
| brown trout (*Salmo trutta*) | 3 | 2 | -- | -- | -- | -- |
| brook trout (*Salvelinus fontinalis*) | 1 | -- | -- | -- | -- | 4 |
| **Cyprinidae** | | | | | | |
| common shiner (*Luxilus cornutus*) | 10 | -- | -- | -- | -- | 58 |
| fallfish (*Semotilus corporalis*) | -- | 34 | 161 | -- | -- | 45 |
| golden shiner (*Notemigonus crysoleucas*) | -- | -- | -- | -- | 5 | -- |
| blacknose dace (*Rhinichthys atratulus*) | -- | -- | 33 | -- | -- | -- |
| longnose dace (*Rhinichthys cataractae*) | -- | 4 | 26 | -- | -- | -- |
| **Catostomidae** | | | | | | |
| white sucker (*Catostomus commersoni*) | 11 | 4 | 12 | 24 | 147 | 2 |
| **Percidae** | | | | | | |
| tesselated darter (*Etheostoma olmstedi*) | 26 | 26 | 35 | 16 | -- | 8 |
| **Ictaluridae** | | | | | | |
| yellow bullhead (*Ameiurus natalis*) | 4 | -- | 1 | 8 | -- | -- |
| **Esocidae** | | | | | | |
| chain pickerel (*Esox niger*) | 6 | 1 | 7 | 2 | -- | 1 |
| **Centrarchidae** | | | | | | |
| largemouth bass (*Micropterus salmoides*) | 8 | 3 | -- | 5 | -- | 2 |
| bluegill (*Lepomis macrochirus*) | 1 | -- | -- | 7 | 5 | 1 |
| pumpkinseed (*Lepomis gibbosus*) | -- | 8 | -- | 11 | 2 | -- |

**Table A7.** Periphyton population and abundance data collected by DWM at selected biomonitoring stations between 9 and 16 July 1998.

| Station # | Location | Date | Habitat | Taxon | Abundance* |
|---|---|---|---|---|---|
| **TB02** (sample 1) | Tatnuck Brook upstream from Williams Millpond, Worcester | 09-Jul-98 | riffle, partly open | *Melosira* | S |
| | | | | *Synedra* | S |
| **TB02** (sample 2) | Tatnuck Brook, upstream from Williams Millpond, , Worcester | 09-Jul-98 | riffle, partly open | moss | |
| | | | | *Melosira* | S |
| | | | | *Spirogyra* | S |
| **KB02** | Kettle Brook downstream from Oxford St., Worcester | 16-Jul-98 | riffle, partly shaded | *Stigeoclonium tenue* | C |
| **KB10** | Kettle Brook, downstream from Earle St., Leicester | 09-Jul-98 | riffle, open | *Spirogyra* | A |
| | | | | *Rhizoclonium* | A |
| | | | | *Lyngbya* | A |
| **BLK01** | Blackstone River, downstream from Millbury St., Worcester | 14-Jul-98 | riffle, partly shaded | *Synedra* | C |
| | | | | *Fragilaria* | C |
| | | | | *Pediastrum* | R |
| | | | | *Melosira* | C |
| | | | | *Phacus* | R |
| | | | | *Scenedesmus* | R |
| | | | | *Actinastrum* | R |
| | | | | *Pandorina* | R |
| | | | | Bacteria | A |
| **BLK01** | Blackstone River, at Millbury St., Worcester | 14-Jul-98 | riffle, partly shaded | moss | |
| | | | | *Melosira* | C |
| | | | | *Fragilaria* | C |
| | | | | *Synedra* | R |
| | | | | *Navicula* | R |
| | | | | *Closterium* | R |
| **BLK07** | Blackstone River, upstream from Sutton St., Northbridge | 15-Jul-98 | riffle, open canopy | *Ulothrix zonata* | A |
| **BLK00A** (sample 1) | Middle River, downstream from Riley Research footbridge, Worcester | 14-Jul-98 | riffle, partly open | *Cymbella* | VC |
| | | | | *Lyngbya* | R |
| | | | | *Scenedesmus* | C |
| | | | | *Stigeoclonium* | C |
| | | | | *Synedra* | R |
| | | | | *Melosira* | R |
| **BLK00A** (sample 2) | Middle River, downstream from Riley Research footbridge, Worcester | 14-Jul-98 | riffle, partly open | *Lyngbya* | S |
| | | | | *Cymbella* | C |
| | | | | *Spirogyra* | S |
| | | | | *Melosira* | S |
| | | | | *Microspora* | S |
| **BLK 15-1** | Mill River, downstream from Summer St., Blackstone | 10-Jul-98 | shallow riffle | moss | |
| | | | | *Fragilaria* | C |
| | | | | *Lyngbya* | S |
| | | | | *Cocconeis* | S |
| **BLK09-8A** | Mumford River, downstream from Manchaug St., Douglas | 15-Jul-98 | riffle, partly shaded | *Microspora pachyderma* | C |
| **WR01** | West River, upstream fr om West River St., Sutton | 15-Jul-98 | riffle, shaded | *Ulothrix* | A |
| | | | | *Mougeotia* | C |
| **BLK02** | Blackstone River, downstream from McCracken Rd., Millbury | 14-Jul-98 | riffle, partly open | *Stigeoclonium* | A |
| | | | | blue green alga | C |
| **RB01** | Dark Brook, downstream from Route 12, Auburn | 10-Jul-98 | riffle, partly open | *Spirogyra* | R |
| | | | | *Synedra* | R |

* abundance abbreviations are as follows: A=abundant; VC=very common; C=common; S=sparse; R=rare

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# APPENDIX D – SUMMARY OF NPDES and WMA PERMITTING INFORMATION, BLACKSTONE RIVER BASIN

**TABLE D1**: Blackstone River Basin - Municipal and Industrial Treatment Plants. . [Note: All general NPDES permits (MAG######) have a flow limit of 1.0 MGD. Volumes in the permitted flow (MGD) column for these facilities were taken from their NPDES general permit applications.]

| | Permittee: | NPDES # | Issuance | Flow | Treatment | Special Notes |
|---|---|---|---|---|---|---|
| Municipal | Upper Blackstone WPAD | MA0102369 | 9/30/1999 | 56.0 MGD | AWT; NH3N & TP | Under appeal |
| | Millbury | MA0100650 | 9/30/1999 | 1.2 MGD | AWT; NH3N & TP | Plans to connect to UB WPAD |
| | Grafton | MA0101311 | 9/30/1999 | 2.4 MGD | AWT; NH3N & TP | Permit appealled |
| | Northbridge | MA0100722 | 9/30/1999 | 2.0 MGD | AWT; NH3N & TP | ---- |
| | Uxbridge | MA0102440 | 9/30/1999 | 2.5 MGD | AWT; NH3N & TP | ---- |
| | Hopedale | MA0102202 | 9/20/1999 | 0.588 MGD | AWT; NH3N & TP | ---- |
| | Douglas | MA0101095 | 9/29/1995 | 0.18 MGD | 2ndry (planning expansion; will be upgraded to AWT) | Will be reissued in 2001 |
| | Upton | MA0100196 | 9/29/1995 | 0.3 MGD | AWT; NH3N & TP | Will be reissued in 2001 |
| | Worcester | MAS010002 | 9/30/1998 | ---- | ---- | Municipal storm water permit |
| | Worcester | MA0102997 | 11/8/1990 | 350 MGD | disinfection | CSO treatment |
| Industrial | Guilford of Maine, E. Douglas | MA0101538 | 12/15/1999 | 1.25 MGD | Biological & sedimentation | Ground water & storm water |
| | New England Plating, Worcester | MA0005088 | 2/24/2000 | 0.20 MGD | Chemical addition; sedimentation for metals removal | Permit under appeal |
| | Wyman Gordon, Grafton | MA0004341 | 6/30/1997 | ---- | Sedimentation | Process wastewater, NCCW, stormwater |
| | Lewcott Corp., Millbury | MA0028592 | 9/2/1992 | ----- | ---- | NCCW |
| | Norton, Co., Worcester | MA0000817 | 7/29/1975 | ---- | Temp = 60-90; 7 outfalls | Uncontaminate d cooling water |
| | Coz Chemical, Northbridge | MA0032549 | 9/29/1995 | | Contact & non-contact cooling water | Will be reissued in spring 2001 |
| | Riverdale Mills Corporation | MAG250279 | | 0.181 MGD | NCCW | Incomplete application |

NCCW = non-contact cooling water

**Table D2.** List of WMA registered and permitted average annual water withdrawals in the Blackstone River Basin (LeVangie, D. 2001. Water Management Act Database. Massachussetts Department of Environmental Protection, division of Watershed Management, Database Manager. Boston, MA.).

| Permit | Registration | PWSID | System Name | Registered Volume (MGD) | 20 Year Permitted Volume (MGD) | Source | G or S | Well/Source Name | Withdrawal location |
|---|---|---|---|---|---|---|---|---|---|
| 9P421230301 | | 2303000 | Upton Department of Public Works | 0 | 0.48 | 01G | G | Glen Avenue Wellfield | Upton |
| 9P421230301 | | 2303000 | Upton Department of Public Works | 0 | 0.48 | 02G | G | West River Street Well | Upton |
| 9P421229001 | | 2290014 | Wilkinsonville Water District | | 0.2 | 03G | G | GP Well #3 | Wilkinsonville |
| 9P21221602 | | | Riverdale Mills Corporation | 0 | 0.3 | | | | |
| 9P321207702 | | | Guilford of ME Finishing Services | 0 | 1.5 | | S | Guilford Pond | East Douglas |
| 9P21227102 | | | Worcester Sand and Gravel, Inc.* | 0 | 0.57 | | G | Well #1 | Shrewsbury, |
| 9P21227102 | | | Worcester Sand and Gravel, Inc.* | 0 | 0.57 | | S | | Shrewsbury, |
| 9P21202501 | | | New England Country Club* | 0 | 0.31 | | S | Pond | Bellingham |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-02G | G | G.P. Well #2 Church St. | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-04G | G | G.P. Well #4 Walsh Ave. | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-07G | G | Well #7 | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-05G | G | G.P. Well #5 Walsh Ave. | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-03G | G | G.P. Well #3 Church St. | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-01G | G | G.P. Well #1 Church St. | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-06G | G | G.P. Well #6 Southbridge | Auburn |
| 9P21201701 | 21201702 | 2017000 | Auburn Water Department | 1.06 | 0.69 | 017-08G | G | Well #8 | Auburn |
| 9P21202502 | 21202501 | 2025000 | Bellingham Water Department | 0.77 | 0.97 | 025-01G | G | P.S. #1 (Cross Street) | Bellingham |
| 9P21202502 | 21202501 | 2025000 | Bellingham Water Department | 0.77 | 0.97 | 025-02G | G | P.S. #2 (Cross Street) | Bellingham |
| 9P21202502 | 21202501 | 2025000 | Bellingham Water Department | 0.77 | 0.97 | 025-04G | G | P.S. #4 (Wrentham Road) | Bellingham |
| 9P21202502 | 21202501 | 2025000 | Bellingham Water Department | 0.77 | 0.97 | 025-11G | G | Well PS #11 | Bellingham |
| 9P21202502 | 21202501 | 2025000 | Bellingham Water Department | 0.77 | 0.97 | 025-03G | G | P.S. # 3 (Wrentham Rd.) | Bellingham |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 032-05G | G | Well #5 | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 032-01G | G | Well #1 | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 032-02G | G | Well #2 | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 2032000-06G | G | Well 5A | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 2032000-07G | G | Well #6 | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 032-04G | G | Well #4 | Blackstone |
| 9P21203201 | 21203201 | 2023000 | Blackstone Water Department | 0.44 | 0.51 | 2032000-08G | G | Well 6A | Blackstone |
| | 21203901 | 2039001 | Morningdale Water District | 0.17 | 0 | 039A02G | G | Well #2 | Boylston |
| | 21203901 | 2039001 | Morningdale Water District | 0.17 | 0 | 039A01G | G | Well #1 | Boylston |
| 9P21207701 | 21207701 | 2077000 | Douglas Water Department | 0.2 | 0.17 | 077-02G | G | West Street Well #2 | East Douglas |
| 9P21207701 | 21207701 | 2077000 | Douglas Water Department | 0.2 | 0.17 | 077-01G | G | West St Tubular Wells | East Douglas |
| | 21211001 | | Wyman-Gordon Company | 3.38 | 0 | | G | Well #4 | North Grafton |
| | 21211001 | | Wyman-Gordon Company | 3.38 | 0 | | G | Well #3A | North Grafton |
| | 21211001 | | Wyman-Gordon Company | 3.38 | 0 | | G | Well #2 | North Grafton |
| | 21211001 | | Wyman-Gordon Company | 3.38 | 0 | | G | Well #1 | North Grafton |
| | 21211001 | | Wyman-Gordon Company | 3.38 | 0 | | S | Hovey Pond/Quinsigamond | North Grafton |
| | 21211002 | 2110001 | South Grafton Water District | 0.2 | 0 | | G | Ferry Street P.S. | South Grafton |
| | 21211002 | 2110001 | South Grafton Water District | 0.2 | 0 | | G | Providence Road P.S. | South Grafton |
| 9P421211004 | 21211004 | 2110000 | Grafton Water District | 0.6 | 0.51 | 110-05G | G | Follette St. Well | Grafton |
| 9P421211004 | 21211004 | 2110000 | Grafton Water District | 0.6 | 0.51 | 110-03G | G | East Street Well #2 | Grafton |
| 9P421211004 | 21211004 | 2110000 | Grafton Water District | 0.6 | 0.51 | 110-02G | G | Worcester Street Well | Grafton |
| 9P421211004 | 21211004 | 2110000 | Grafton Water District | 0.6 | 0.51 | 110-04G | G | East Street Well #3 | Grafton |

*indicates permitted withdrawal for less than 365 days, ** indicates registered withdrawal for less than 365 days, G – ground water, S – source water

**Table D2. Continued.** List of WMA registered and permitted average annual water withdrawals in the Blackstone River Basin (LeVangie 2001).

| Permit | Registration | PWSID | System Name | Registered Volume (MGD) | 20 Year Permitted Volume (MGD) | Source | G or S | Well/Source Name | Withdrawal location |
|---|---|---|---|---|---|---|---|---|---|
| | 21213801 | | Hopedale Country Club** | 0.1 | 0 | | | Mill River | |
| | 21213802 | 2138000 | Hopedale Water Department | 0.41 | 0 | 138-01G | G | Mill Street Wellfield | Hopedale |
| | 21215101 | 2151000 | Leicester Water Supply District | 0.19 | 0 | 151-01G | G | #1 Well | Paxton |
| | 21215101 | 2151000 | Leicester Water Supply District | 0.19 | 0 | 151-04G | G | Jim Dandy | Paxton |
| | 21215101 | 2151000 | Leicester Water Supply District | 0.19 | 0 | 151-03G | G | #3 Well | Paxton |
| | 21215101 | 2151000 | Leicester Water Supply District | 0.19 | 0 | 151-02G | G | #2 Well | Paxton |
| | 21217902 | | Miscoe Springs Inc. | 0.06 | 0 | | G | Well #1 | Mendon |
| 9P21218601 | 21218602 | 2186000 | Mass. American Water Co.-Millbury | 1.03 | 0.99 | 186-01G | G | Millbury Avenue Dug Well | Millbury |
| 9P21218601 | 21218602 | 2186000 | Mass. American Water Co.-Millbury | 1.03 | 0.99 | 186-02G | G | Oak Pond Well | Millbury |
| 9P21218601 | 21218602 | 2186000 | Mass. American Water Co.-Millbury | 1.03 | 0.99 | 186-03G | G | North Main #1 | Millbury |
| 9P21218601 | 21218602 | 2186000 | Mass. American Water Co.-Millbury | 1.03 | 0.99 | 186-04G | G | North Main #2 | Millbury |
| | 21218603 | | Polyclad Laminates, Inc. | 0.11 | 0 | | S | Polyclad intake | Millbury |
| | 21218604 | | Concrete Service Inc.** | 1.08 | 0 | | S | Wash Water Pump #2 | Grafton |
| | 21218604 | | Concrete Service Inc.** | 1.08 | 0 | | S | Concrete Mix Plant #1 | Grafton |
| | 21218604 | | Concrete Service Inc.** | 1.08 | 0 | | G | Well #2 | Millbury |
| | 21218604 | | Concrete Service Inc.** | 1.08 | 0 | | G | Domestic Well #3 | Grafton |
| | 21218604 | | Concrete Service Inc.** | 1.08 | 0 | | S | C-1 | Millbury |
| 9P21221601 | 21221601 | 2216000 | Whitinsville Water Company | 1.09 | 0.34 | | G | Sutton Well Field | Sutton |
| 9P21221601 | 21221601 | 2216000 | Whitinsville Water Company | 1.09 | 0.34 | | G | Whitin Well Field | Northbridge |
| | 21221602 | | Coz Realty Trust | 0.32 | 0 | Well #1 | G | Railroad Street | Northbridge |
| | 21221602 | | Coz Realty Trust | 0.32 | 0 | | G | Well #2 | Northbridge |
| | 21221603 | | Whitinsville Golf Club** | 0.05 | 0 | | S | Whitinsville GC | Whitinsville |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-03G | G | Oak Street Well | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-05G | G | Lambert's #3-2 | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-04G | G | Lambert's #3-1 | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-06G | G | Sewell Street #5 | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-01G | G | South Street #1 | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-02G | G | Sewell Street #4 | Shrewsbury |
| 9P21227101 | 21227101 | 2271000 | Shrewsbury Water & Sewer Department | 2.64 | 1.01 | 271-07G | G | Home Farm #6 | Shrewsbury |
| | 21229002 | | Pleasant Valley Country Club** | 0.16 | 0 | | S | Cogan Pond | Sutton |
| 9P21230401 | 21230401 | 2304000 | Uxbridge Water Department | 0.66 | 0.58 | 2304000-02G | G | Well #2 | Blackstone |
| 9P21230401 | 21230401 | 2304000 | Uxbridge Water Department | 0.66 | 0.58 | 2304000-03G | G | Well #3 | Blackstone |
| 9P21230401 | 21230401 | 2304000 | Uxbridge Water Department | 0.66 | 0.58 | 2304000-05G | G | Bernat Well #3 | Uxbridge |
| 9P21230401 | 21230401 | 2304000 | Uxbridge Water Department | 0.66 | 0.58 | 2304000-04G | G | Bernat Well #2 | Uxbridge |
| 9P21230401 | 21230401 | 2304000 | Uxbridge Water Department | 0.66 | 0.58 | 2304000-01G | G | Well #1 | Blackstone |
| 9P21234802 | 21234801 | | Norton Company | 0.42 | 0.15 | | G | Brooks Street Well | Worcester |
| 9P21234802 | 21234801 | | Norton Company | 0.42 | 0.15 | | G | Higgins Street Well | Worcester |
| 9P21234802 | 21234801 | | Norton Company | 0.42 | 0.15 | | G | New Bond Street Well | Worcester |
| 9P21234802 | 21234801 | | Norton Company | 0.42 | 0.15 | | G | Ararat Street Well | Worcester |
| 9P21234802 | 21234801 | | Norton Company | 0.42 | 0.15 | | G | C Street Well | Worcester |
| | 21234802 | | Cincinnati Milacron-Heald Corp. | 0.49 | 0 | | G | Well #1 (Boiler Room) | Worcester |
| | 21234802 | | Cincinnati Milacron-Heald Corp. | 0.49 | 0 | | G | Well #2 (Back Gate) | Worcester |
| | 21234803 | | Tatnuck Country Club** | 0.05 | 0 | | S | C-1 | Worcester |
| | 21234803 | | Tatnuck Country Club** | 0.05 | 0 | | G | Well #1 | Worcester |

*indicates permitted withdrawal for less than 365 days, ** indicates registered withdrawal for less than 365 days, G – ground water, S – source water

**Table D2. Continued.** List of WMA registered and permitted average annual water withdrawals in the Blackstone River Basin (LeVangie 2001).

| Permit | Registration | PWSID | System Name | Registered Volume (MGD) | 20 Year Permitted Volume (MGD) | Source | G or S | Well/Source Name | Withdrawal location |
|---|---|---|---|---|---|---|---|---|---|
| | 21234804 | | Worcester Country Club** | 0.1 | 0 | | S | | Worcester |
| | 21234805 | 2348000 | Worcester Department Public Works | 14.22 | 0 | | G | Shrewsbury Well | Shrewsbury |
| | 21234805 | 2348000 | Worcester Department Public Works | 14.22 | 0 | | S | Holden Meter | Worcester |
| | 21234805 | 2348000 | Worcester Department Public Works | 14.22 | 0 | | S | Olean Street Pump Sta | Worcester |
| | 21234805 | 2348000 | Worcester Department Public Works | 14.22 | 0 | 348-01S | S | Lynde Brook | Leicester |
| | 21234805 | 2348000 | Worcester Department Public Works | 14.22 | 0 | | S | Apricot Meter | Worcester |
| 9P241221201 | 41221101 | 4211000 | North Attleboro Water Department | 0.43 | 0.64 | 211-08G | G | Adamsdale well | North Attleboro |
| 9P241221201 | 41221101 | 4211000 | North Attleboro Water Department | 0.43 | 0.64 | | G | Girl Scout Well | N. Attleboro |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | G | Well B (WB) | Wrentham |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | S | Pond D (D) | Wrentham |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | S | Pond C (C) | Wrentham |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | S | Pond B (B) | Wrentham |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | G | Well A (WA) | Wrentham |
| | 41235001 | | Big Apple Realty Trust | 0.08 | 0 | | S | Pond A (A) | Wrentham |

* indicates permitted withdrawal for less than 365 days, ** indicates registered withdrawal for less than 365 days, G – ground water, S – source water

# APPENDIX E - DEP 1999 GRANT AND LOAN PROGRAMS

Excerpted from the DEP/DWM World Wide Web site, http://www.state.ma.us/dep/brp/wm/wmpubs.htm#other '1999 Grant and Loan Programs - Opportunities for Watershed Planning and Implementation'.

604(b) WATER QUALITY MANAGEMENT PLANNING GRANT PROGRAM
This grant program is authorized under the federal Clean Water Act Section 604(b) for water quality assessment and management planning. 604(b) projects in the Connecticut River Watershed include:

- 98-03/604 *Upper Blackstone Watershed Wetlands Restoration Planning Project.* The project involves preparation of an upper Blackstone River Watershed Wetlands Restoration Plan that complies with the technical and planning criteria of the Massachusetts Wetlands Restoration & Banking Program. This includes: updating wetlands map data; identifying, characterizing and mapping potential wetlands restoration sites; establishing a digital wetlands database; evaluating how wetlands restoration can help improve the watershed in terms of water quality, flood storage, fish habitat, and wildlife habitat. The project will be carried out by the Worcester County Conservation District in cooperation with the WRBP and UMASS Amherst

104(b)(3) WETLANDS AND WATER QUALITY GRANT PROGRAM
This Grant Program is authorized under Wetlands and Clean Water Act Section 104(b)(3) of the federal Clean Water Act. The Water Quality proposals received by DEP under this National Environmental Performance Partnership Agreement (NEPPA) with the U.S. Environmental Protection Agency is a results oriented approach that will focus attention on environmental protection goals and the efforts to achieve them. The goals of the NEPPA are to: 1) achieve clean air, 2) achieve clean water, 3) protect wetlands, 4) reduce waste generation, and 5) clean up waste sites.

319 NONPOINT SOURCE GRANT PROGRAM
This grant program is authorized under Section 319 of the CWA for implementation projects that address the prevention, control, and abatement of nonpoint source (NPS) pollution. In order to be considered eligible for funding projects must: implement measures that address the prevention, control, and abatement of NPS pollution; target the major source(s) of nonpoint source pollution within a watershed/subwatershed; have a 40 percent non-federal match of the total project cost (match funds must meet the same eligibility criteria as the federal funds); contain an appropriate method for evaluating the project results; address activities that are identified in the Massachusetts NPS Management Program Plan.

RESEARCH AND DEMONSTRATION GRANT PROGRAM
The Research and Demonstration Program (R&D) is authorized by section 38 of Chapter 21 of the Massachusetts General Laws and is funded by proceeds from the sale of Massachusetts bonds. Specifically, the R&D Program was established to enable the Department to conduct a program of study and research and demonstration relating to water pollution control and other scientific and engineering studies "...so as to insure cleaner waters in the coastal waters, rivers, streams, lakes and ponds of the Commonwealth."

SOURCE WATER AND TECHNICAL ASSISTANCE/LAND MANAGEMENT GRANT PROGRAM
The Source Water Protection Technical Assistance/Land Management Grant Program provides funds to *third party* technical assistance organizations that assist public water suppliers in protecting local and regional ground and surface drinking water supplies.

WELLHEAD PROTECTION GRANT PROGRAM
The Wellhead Protection Grant Program provides funds to assist public water suppliers in addressing wellhead protection through local projects and education.

- 99-03/WHP *Douglas Wellhead Protection Project.* This project will install and/or upgrade fencing around the Zone I areas and will install an asphalt berm to reduce stormwater runoff from washing into the well field. New fencing will prevent vehicles from gaining access to the Glen Street and West

Street well fields and will provide additional security to the pump stations. The berm will reduce the threat of contaminants by directing runoff into an existing catch basis.

- 99-04/WPH *Bellingham Wellhead Protection Project*. This project will relocate subsurface wastewater disposal outside of the Zone I for well #3. The long-term water quality of this source is threatened by a septic system located within 200 feet of the pump station and well. This septic system will be properly abandoned and a new system will be constructed outside of the Zone I.
- 99-09/WPH *Auburn Wellhead Protection Area*. This project will augment the District's Emergency Response Plans to address hazardous materials spills; it will compile drainage maps of roads near wells; identify potential contamination migration pathways; educate local officials, and conduct stormwater sampling. Given the proximity of Auburn's most productive drinking water wells to the Turnpike, I-290, and Route 12, a master drainage plan will be a vital component of wellhead protection planning. Although road salt has compromised the water quality of the wells, potential releases of oil or hazardous materials on these major roadways represents a threat that could result in long term or permanent loss of these valuable sources of drinking water.
- 99-13/WPH *Upton Wellhead Protection Area*. This project will expand two existing town staff positions to carry out new responsibilities for wellhead protection and public education. The project will also complete a Wellhead Protection plan and install protective fencing at the Zone I of the Glen Avenue Wellfield.

CLEAN WATER STATE REVOLVING LOAN FUND (SRF) PROGRAM

The Massachusetts State Revolving Fund for water pollution abatement projects was established to provide a low-cost funding mechanism to assist municipalities seeking to comply with federal and state water quality requirements. The SRF Program is jointly administered by the Division of Municipal Services of the Department of Environmental Protection and the Massachusetts Water Pollution Abatement Trust. Each year the Department solicits projects from Massachusetts municipalities and wastewater districts to be considered for subsidized loans, which are currently offered at 50% grant equivalency (approximates a no-interest loan). In recent years the program has operated at an annual capacity of $150 to $200 million per year, representing the financing of 40 to 50 projects annually. The SRF Program now provides increased emphasis on watershed management priorities. A major goal of the SRF Program is to provide incentives to communities to undertake projects with meaningful water quality and public health benefits and which address the needs of the communities and the watershed.

- *643-C Northbridge WWTP*. The objective of this project is to upgrade the existing wastewater treatment plant in order to comply with discharge limits for organics, nutrients, and metals, as well as provide improved removals of BOD and suspended solids. The upgraded plant, designed for a daily average flow of 2.0 MGD will include Sequential Batch Reactors for nitrification, a chemical feed system for phosphorus removal (a new UV disinfection system was previously installed) and elimination of obsolete equipment.
- *635-P UBWPAD*. Pilot scale work will be undertaken to evaluate alternative treatment technologies for biological nutrient removal and high flow management. This project is a continuation of District planning efforts previously approved in 1998 and 1999 for 1.08 million SRF financing.

COMMUNITY SEPTIC MANAGEMENT PROGRAM

The enactment of the Open Space Bond Bill in March of 1996 provided new opportunities and stimulated new initiatives to assist homeowners with failing septic systems. The law appropriated $30 million to the DEP to assist homeowners. The Department will use the appropriation to fund loans through the Massachusetts Water Pollution Abatement Trust. The fund will provide a permanent state/local administered revolving fund to assist income-eligible homeowners in financing necessary Title 5 repairs. Working together, the DEP and the Trust have created the Community Septic Management Program to help Massachusetts' communities protect threatened ground and surface waters while making it easier to comply with Title 5. This loan program offers three options from which a local governmental unit can choose.

MASSACHUSETTS DRINKING WATER STATE REVOLVING FUND PROGRAM

The Massachusetts Drinking Water State Revolving Fund (DWSRF) provides low-cost financing to help community public water suppliers comply with federal and state drinking water requirements. The DWSRF Program's goals are to protect public health and strengthen compliance with drinking water requirements, while addressing the Commonwealth's drinking water needs. The Program incorporates affordability and

watershed management priorities. The DWSRF Program is jointly administered by the Division of Municipal Services of the Department of Environmental Protection (DEP) and the Massachusetts Water Pollution Abatement Trust (Trust). This month, DEP will solicit projects from Massachusetts municipalities and community water systems (with at least 15 residential connections) to be considered for subsidized loans. The current subsidy level is equivalent to a 50% grant, which approximates a *no-interest loan.* The Program will initially operate with approximately $50 million in financing capacity. For calendar years 1998 through 2003, up to $400 million may be available through the loan program.

MASSACHUSETTS WATERSHED INITIATIVE

99-03/604 *Beaver Brook Daylight Project.* It is proposed that a 3500 foot reach of Beaver Brook presently existing as a culverted channel be replaced by a 16 foot wide open channel. Side slopes and a 50 foot wide riparian corridor would be vegetated with shrubs and trees. Boulders and deflectors would be added to provide instream habitat for fish and other aquatic life. A system of small ponds and marsh would be constructed to improve water quality and provide additional fish and wildlife habitat. Approximately 2 acres of an adjacent parking lot would be restored to provide additional green space.

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# APPENDIX F
# DEP TECHNICAL MEMORANDUM
# 1993 MUMFORD RIVER BENTHIC MACROINVERTEBRATE BIOMONITORING:
## UPSTREAM/DOWNSTREAM COMPARISON OF POINT SOURCE DISCHARGE EFFECTS

To: Blackstone River Basin Team

From: John Fiorentino

Date: 13 February 1997

## INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts on the aquatic community. Resident biota (e.g. benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic as well as cumulative pollution and habitat alteration (Plafkin et al. 1989, Barbour et al. 1995). Biological surveys and assessments are the primary approaches to biomonitoring.

The Office of Watershed Management conducted biomonitoring at 4 stream sites to bracket the effects of the East Douglas POTW and the Guilford of Maine Inc. discharges on the benthic macroinvertebrate community. An upstream/downstream (site-specific) sampling approach was implemented, in which the aquatic community and habitat below the discharge (downstream study site) was compared to an upstream control site representative of the "best attainable" conditions in the waterbody. While the alternative to this site-specific approach is to compare the study site to a regional reference station, the site-specific approach is more appropriate for an assessment of an impact site (Plafkin et al. 1989). Sampling methodology was based on USEPA Rapid Bioassessment Protocols (RBP)--a biosurvey, which focused on the standardized sampling of benthic macroinvertebrates, was supplemented with a habitat assessment to evaluate water quality and habitat quality at each study site.

## METHODS

The macroinvertebrate collection procedure utilized kick sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms downstream with an aquatic net. Sampling was conducted in riffle/run areas with fast currents and cobble and gravel substrates--generally the most productive habitats, supporting the most diverse communities in the stream system. A kick net with an opening approximately 0.45 m wide and a mesh size of 590 microns was used to collect a sample from an approximately 1 $m^2$ area. Two 1 $m^2$ samples were collected at each station--one from an area of fast current velocity and one from an area of slower current velocity. The two samples were then combined to produce a single composite sample.

In the field, a subsample of 100 macroinvertebrates was separated from the original composited sample collected at each site. Specimens were identified to family (Rapid Bioassessment Protocol II, or RBP II) in the laboratory to the extent their condition allowed. Based on this family-level taxonomy, various community, population, and functional parameters, or "metrics," are calculated which allow an investigator to measure important aspects of the biological integrity of the community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated. Deficiency of any one metric should not invalidate the entire approach (Plafkin et al. 1989). The percent comparability of study site metric scores to those for a selected unimpaired reference station (i.e. "best attainable" situation) yields an impairment score for each site. RBP II analysis separates sites into three categories: non-impaired, moderately impaired, and severely impaired. Impairment of the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989).

RBP II also utilizes a habitat assessment matrix for rating habitat quality, an integral component in the final evaluation of impairment. The habitat assessment is intended to support the biosurvey and enhance the interpretation of the biological data. The matrix used to assess habitat quality is based on key physical characteristics of the water body and surrounding land use. All parameters evaluated are related to overall land use and are potential source of limitation to the aquatic biota (Plafkin et al. 1989). The habitat parameters included in the matrix were evaluated at all sites sampled in the Mumford River. Ratings were then totaled and compared to an upstream reference station to provide a final habitat ranking.

It is important to recognize that Rapid Bioassessment Protocol II is primarily a semi-quantitative screening tool which allows agencies to evaluate a large number of sites with relatively limited time and effort. The protocol is best used to prioritize sites for more intensive evaluation, such as RBP III, toxicity testing, or quantitative replicate sampling. The information derived from RBP II provides a basis for ranking sites as non, moderately, or severely impaired. This classification can then be used to focus on additional study or regulatory action.

## RESULTS

Biomonitoring data collected from the Mumford River are attached as an appendix. Table 1 is a site description summary of the four biomonitoring stations, including a brief description of the various habitat parameters evaluated. Table 2 includes a summary of the site location, habitat evaluations, and stream discharge information for the four sample stations. Table 3 is the family-level taxonomic list of macroinvertebrates collected from each site. The taxa list includes total organism counts, and the functional feeding group (FFG) and tolerance value (TV) of each taxon. Also included in the appendix is a summary table (Table 4) for the RBP II data analysis, including biological metric calculations, metric scores, and final impairment scores. Habitat assessment scores for each station are also included in the summary table.

MF03A--Mumford River, East Douglas MA (7 September 1993)

HABITAT

MF03A was located in the Mumford River approximately 100 m upstream from the treated wastewater discharge of the East Douglas POTW (NPDES # MA0101095). A description of the stream reach sampled is included in Table 1. MF03A received a habitat assessment score of 115 out of a possible 135. Those primary instream habitat parameters directly pertinent to the support of aquatic communities and weighted the highest in the assessment matrix--substrate type and stability, availability of refugia, and velocity/depth regimes--scored well (Table 2). MF03A was designated as the site-specific control (upstream reference) station, in an attempt to bracket discharge effects on the downstream community. While it is impossible to find a non-impacted stream in the Blackstone River Basin, MF03A was determined to represent the "best attainable" conditions in the Mumford River in terms of habitat and water quality.

BENTHOS

A taxonomic list of macroinvertebrates collected at MF03A can be found in Table 3. Because MF03A is a reference station, it does not receive an impairment score for the aquatic community found there. However, the metric values (Table 4) calculated as part of the RBP II analysis seem to reflect the healthy benthic community one would expect to find in a "least impacted" stream. In particular, those parameters that measure components of community structure (taxa richness, family biotic index, and EPT index)--which display the lowest inherent variability among the RBP metrics used (Resh 1988)--scored well and corroborate the designation as a reference station. The dominance of filter-feeders (Philopotamidae, Oligoneuriidae, and especially Hydropsychidae) at MF03A is not surprising, as the extensive wetland margins upstream of the sampling reach offer substantial organic inputs in the form of allochthonous materials. Through a variety of abiotic and biotic processes, these organic materials become available as high quality Fine Particulate Organic Material (FPOM) for filter-feeders such as Hydropsychidae, who use silken nets to capture this food resource as it is suspended in the water column. In addition, an

impoundment upstream of MF03A is a potential source of organic enrichment and associated suspended FPOM for the downstream community (Wiederholm 1984).

MF03B--Mumford River, East Douglas MA (7 September 1993)

HABITAT

MF03B was located immediately downstream from the East Douglas POTW effluent discharge in the "incomplete" mixing zone; in fact, the first kick sample was collected from a riffle area located in the effluent plume, while a second riffle was sampled a few meters further downstream at the clear water edge of the river/plume interface. The effluent seemed particularly bad--very gray and turbid in appearance (Nuzzo personal communication). It was impossible to conduct sampling further downstream in the mixing zone, due to the immediate impounding of the river below the sampling reach producing a habitat much different from the upstream control site and unsuitable for the RBP sampling protocol.

As in the upstream station MF03A, stable cobble/rubble and gravel substrates provided excellent habitat for macroinvertebrates. Fish cover was exceptional as well, with an abundance of submerged logs and undercut banks present. Flow regimes and velocity/depth combinations were good. Additional habitat parameters ranged from good to excellent (Table 2). Some fairly embedded substrates were observed outside of the sample areas, probably the result of deposited fine organic materials related to the discharge. MF03B received a habitat assessment score of 112, which is 97% comparable to the upstream reference station. In addition, mean velocity and stream discharge rates (Table 2) were highly similar to those at MF03A. The strong comparability to the reference station in terms of habitat type and quality, coupled with similar stream flow conditions, allow a direct comparison of biological condition between upstream and downstream stations. That habitat quality is similar at both sites, infers that detected impacts--if any--at the study site, can be attributed to water quality factors. Sampling of highly similar habitats will also reduce the variability in those metrics (e.g. taxa richness, EPT index) attributable to factors such as current speed and substrate type (Plafkin et al. 1989).

BENTHOS

MF03B received a total metric score of 6 out of a possible 42, representing only a 14% comparability to the upstream reference station (Table 4). The severely impaired biological condition is clearly a result of water quality degradation due to discharge effects. The diverse, pollution-intolerant macroinvertebrate assemblage found upstream of the discharge has been replaced by fewer (taxa richness=12), more tolerant taxa (biotic index=6.19) representative of an impaired and unbalanced benthic community. The disproportionate number of the Chironomidae (Table 3) relative to the more sensitive groups (EPT/Chironomidae=0.30) is also quite indicative of environmental stress (Plafkin et al. 1989). This dominance of the community by Chironomidae, coupled with the low EPT index (5) and high family biotic index (developed to detect organic pollution and based on organism tolerance to low dissolved oxygen levels) value indicate a community structured in response to increased enrichment (nutrient and/or organic) and subsequent low levels of dissolved oxygen.
In addition to inorganic and/or organic pollutant inputs to the aquatic community at MF03B, the macroinvertebrate assemblage indicates that toxicants may be present as well. The decrease in filter-feeders is especially significant, as this feeding group is very sensitive to toxicants bound to fine particles and is the first to decrease when exposed to a steady source of such bound toxicants (Plafkin et al. 1989). By readily adsorbing to dissolved organic matter (DOM) forming fine particulate organic material during flocculation, these toxicants become available to filterers via the FPOM food resource. While densities of filter-feeders and other less tolerant taxa (e.g. EPTs) are expected to decline when exposed to toxic stressors, increases are expected in the numbers of Chironomidae and Oligochaeta, which display high tolerance to these extreme conditions (Wiederholm 1984). Indeed, while these highly tolerant taxa (Oligochaeta: Naididae, Tubificidae, and especially Lumbriculidae; Chironomidae) were scarce at the upstream reference station, they dominated the macroinvertebrate assemblage at MF03B. The macroinvertebrate data, then, may prove to be a useful compliment to results from effluent toxicity testing at the East Douglas POTW.

It is important to exercise caution when attempting to distinguish the relative impact of multiple factors, or "stressors," causing aquatic community degradation at a study site. At the MF03B station, a conservative approach should be taken in the interpretation of macroinvertebrate data to determine whether organic or toxic problems are of greater importance to the aquatic community. While the oligochaete Lumbriculidae is more strongly associated with toxicants than with organic pollution, the Tubificidae taxon may (e.g. *Tubifex tubifex, Limnodrilus hoffmeisteri*) or may not be an organic indicator, depending on the species found representing this group. Likewise, the Chironomidae taxon is potentially a toxic indicator; however, increased taxonomic resolution of this group at the MF03B site is necessary to confirm toxic effects, as some Chironomidae are highly tolerant of toxicants (e.g. *Cricotopus* sp.) while others display low tolerance. Additional taxonomic identification (genus/species) of organisms at MF03B, then, may shed more light on possible causes of impairment relating to the East Douglas POTW discharge. This approach is further warranted in the absence of any physicochemical data for this sampling station.

While the effects of gross organic or toxic pollution on the benthic community are a primary cause of impairment from wastewater treatment plants, excessive temperature effects will be briefly mentioned. Industrial discharges are often responsible for the alteration of thermal regimes in a water body and the subsequent influence on the ecology of aquatic invertebrates below those discharges (Wiederholm 1984). Variation in temperature tolerance occurs within insect groups. For example, the lethal limits for some species of Plecoptera and Ephemeroptera are around 20°C, while several species of Chironomidae have been shown to be considerably more hardy (Wiederholm 1984). While increases to temperature in the mixing zone below the East Douglas POTW discharge may contribute to the displacement of EPT taxa by high densities of Chironomidae, the unfortunate lack of temperature data at this station leads to speculative assumptions at best.

MF04A--Mumford River, East Douglas MA (9 September 1993)

HABITAT

MF04A was located immediately below Gilboa Pond, and approximately 200 m upstream from the confluence with Gilboa Brook. The station served as the upstream control for the MF05 study site in an attempt to bracket the discharge effects of Guilford of Maine Inc. (NPDES #MA0001538), a textile manufacturer whose discharge outfalls (treated process wastewater, cooling water, storm drain) entered (in 1993) Gilboa Brook a short distance upstream from the confluence with the Mumford River. The presence of Phosphorus in the Guilford effluent is a major concern, as initiative studies in the Blackstone River Basin have demonstrated that low levels of dissolved oxygen and high BOD loads resulting from nutrient inputs are the leading causes of eutrophication in ponds, lakes, and small rivers such as the Mumford. Guilford of Maine also possessed a Water Management Act (WMA) permit to withdraw water from Gilboa Pond for use at its facility. To prevent withdrawal impacts to the downstream aquatic community, the facility was required to release a minimum of 16 cfs from the impoundment to the Mumford River, thereby ensuring a minimum base flow downstream.

As described in Table 1, macroinvertebrate habitat at MF04A was excellent, with a variety of substrates available and little embeddedness. Flow throughout the reach was good, as was the variety of velocity/depth combinations. The station received a habitat assessment score of 99 (Table 2).

BENTHOS

The macroinvertebrate community structure and composition at MF04A appear to be directly related to its location immediately downstream from Gilboa Pond. Not only does this impoundment receive the mixed effluent from the East Douglas POTW, it is also bordered by extensive agricultural activities--particularly alfalfa crops with known manure spreading practiced. Subsamples taken from the original composite sample revealed exceptionally high densities of Hydropsychidae--70 individual organisms were found in the first two subsample grids (note in Table 3 that counts for this taxon are excluded). That the assemblage is dominated by this filter-feeder is not surprising, as the impoundment no doubt is a contributing source of suspended fine particulate organic material; however, the sheer numbers represented by this taxon are somewhat disconcerting and indicative of effects from excessive upstream enrichment. Typically, in lentic systems such as the impoundment upstream of MF04A, the primary

source of organic matter is autochthonous (produced within the system), with secondary inputs of allochthonous (transported into the system from someplace else) materials from shoreline vegetation and fluvial inputs (Wetzel 1974, Merritt et al. 1984). Phytoplankton production--and to a lesser extent, littoral vascular plant production--and associated dissolved organic matter (DOM), are the primary source of autochthonous matter (Wetzel 1975). It is the physical-chemical flocculation of this DOM which leads to the formation of FPOM, the primary nutrition resource utilized by filter-feeders such as Hydropsychidae (Wetzel 1975). While FPOM production in lotic systems is primarily a result of the processing of microbially colonized Course Particulate Organic Material (CPOM) by aquatic shredders, the high concentration of FPOM in stream systems immediately below pond and reservoir outlets has mainly lentic origins. If these lentic systems are subjected to increasingly eutrophic conditions from excessive inorganic/organic inputs--such as, in this case, from the East Douglas POTW and/or local agricultural practices--the resulting effects of enrichment (i.e. increased algal, plant, and DOM production) can be seen not only in the lentic fauna, but also the aquatic communities immediately downstream. The rich filter-feeding invertebrate assemblage at MF04A appears to reflect the effects of considerable upstream enrichment, and is indicative of an unbalanced community responding to an overabundance of a food source. In addition, the somewhat low taxa diversity (12), reduction of EPT taxa (5), and especially, the high biotic index (6.14) indicate potentially low levels of dissolved oxygen--probably a result of increased biological oxygen demand in Gilboa Pond from organic and nutrient inputs related to agricultural activity (e.g. inorganic and organic forms of Nitrogen and Phosphorus from manure and fertilizers) or the East Douglas POTW. It is difficult to make valid generalizations on the effects of pesticides and/or herbicides--if any--on the aquatic community downstream of Gilboa Pond; however, the macroinvertebrate assemblage shows little indication of toxic effects--filter-feeders are abundant (before exclusion of Hydropsychidae from subsampes) and Chironomidae density is not excessively high,

It was the decision of DEP biologists to eliminate the Hydropsychidae taxon from the macroinvertebrate community analysis at both MF04A and the downstream study site MF05. This approach would allow--to some extent--the elimination of detected upstream enrichment effects (i.e. from the East Douglas POTW, agriculture practices that cause organic/nutrient loading to Gilboa Pond, and other anthropogenic-induced enrichment) and a better "teasing out" of potential water quality impairment effects from the Guilford effluent discharge. The resulting macroinvertebrate assemblage at MF04A, then, exhibits a fairly low percent contribution of the dominant family (19%). Scores for the seven biological metrics totaled 42.

MF05--Mumford River, Uxbridge MA (9 September 1993)

HABITAT

The MF05 study site was located approximately 100 m downstream from the confluence with Gilboa Brook, a small first order tributary that received the Guilford stormwater, cooling water, and treated wastewater discharges. The site description summary (Table 1) concludes that bottom substrates, composed of cobble and gravel and subjected to a variety of velocity/depth combinations, offered excellent habitat for macroinvertebrates. Remaining habitat parameters were considered good or excellent (Table 2), resulting in a total habitat assessment score (111) that was higher than that for the upstream reference station MF04A. In addition to comparable habitat quality to the reference site, stream velocity and discharge in the MF05 sampling reach were very similar to those flow conditions at MF04A (Table 2). Final conclusions regarding the presence and degree of biological impairment, then, can be made based on the assumption that water quality, not habitat quality, is the limiting factor.

BENTHOS

RBP II analysis of the macroinvertebrate community at MF05 was based on a 100 organism subsample that excluded Hydropsychidae. As with the MF04A station, exceedingly high densities of this taxon were present in the original sample (150 individuals were found in the first few gridded subsamples alone!). A total metric score of 33, representing a 79% comparability to the upstream reference site, placed the biological condition of MF05 in the non-impaired category. In fact, several of the metrics values (taxa richness, biotic index, EPT/Chironomidae) for the MF05 macroinvertebrate community were better than those for the reference station.

The macroinvertebrate assemblage at MF05, like MF04A, indicates the presence of significant amounts of FPOM. This food source is available as suspended material in the water column and as settled, decomposing material. Lumbriculidae, a gatherer of particulate organic matter, and the filter-feeding Oligoneuriidae are common taxa (Table 1). In addition, the high density (51) of the scraper Heptageniidae indicates that attached algae and associated materials are a contributing food resource as well. While the overabundance of particulate organic materials at MF05 is indicative of upstream enrichment, the non-impairment score infers that it is primarily the multiple stressors originating from Gilboa Pond and further upstream--not Guilford of Maine--that are shaping the aquatic community composition at MF05 (although the density of the "excluded" Hydropsychidae is two times greater than at MF04B, suggesting Guilford may be a contributing source of enrichment as well). It is important, then, to exercise caution when interpreting the impairment score for this station, as the evaluation is relative to the upstream reference station--a community that is, in reality, probably not representative of "best attainable" conditions for the Mumford River.

Since the 1993 biosurvey, the Guilford of Maine Inc. wastewater outfall has been removed and relocated, and is now discharging directly to the mainstem Mumford River. Relocation was necessary due to the company's inability to meet the stringent limits imposed by the low dilution requirements of Gilboa Brook. The 1993 sampling effort will therefore be available as a "before" picture of water quality for any subsequent monitoring in this portion of the Mumford River. A before/after comparison in Gilboa Brook is, unfortunately impossible, as this stream was not monitored in 1993. While effluent, cooling stream (although the Guilford discharge is technically not thermal in nature), and storm drain inputs apparently caused minimal or no impairment to the Mumford River, these discharges may have had pronounced impacts on the biological community in Gilboa Brook where the capacity to assimilate discharge loads is considerably less than in the main stem.

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**APPENDIX**

Table 1. Site description of biomonitoring stations (MF03A, MF03B, MF04A, MF05) sampled in the Mumford River on 7 and 9 September 1993 as part of the Blackstone River Basin survey.

| | |
|---|---|
| MF03A | Bottom substrates and available cover in the stream reach sampled were considered excellent. The cobble/gravel substrates were slightly embedded, although there was no evidence of erosion or other nonpoint source pollution. The riffle/run habitat was partly shaded by overhanging vegetation including maples, white ash, hop hornbeam, and river grape. The streambanks were well stabilized. Stream width varied from 5.8 to 7.3 m, while depth ranged from 15 to 30 cm in the riffles to 0.76 cm in the runs. Pool habitat was limited. |
| MF03B | Stable cobble/rubble and gravel substrates provided excellent habitat, as in the upstream station MF03A. Cover was better in this segment of the stream, however, and included submerged logs and undercut banks. This stream reach received wastewater from the East Douglas POTW which resulted in a very turbid plume visible instream. The effluent plume was mixed to approximately2/3 of the stream width at the downstream end of the reach sampled. Some increase in embeddedness of bottom substrates was evident due to the wastewater discharge. Deposition of fine sediment occurred along the banks at the downstream end of the stream segment. Deeper riffle (15 to 46 cm) and pool habitat (0.76 to 0.91 cm) was available in this segment of the Mumford River. Red maple overgrown with river grape provided shade to abouthalf the reach. |
| MF04A | Bottom substrates, comprised of cobble/gravel and sand, were considered excellent. Available cover was good and included undercut banks and some emergent aquatic vegetation. Embeddedness did not appear to be a problem, although some alteration of the streambed (loose "sawdust" type material which became suspended quite easily) was evident from recent construction activities associated with the placement of an instream diffusor pipe for Guilford Industries. The canopy was primarily open, although some shade was provided by alder and red maple. Stream width was fairly uniform at approximately 6.1 m. Depth ranged from 15 to 30 cm in the runs to 1.5 m in the pools. |
| MF05 | This segment of the Mumford River was characterized as having excellent substrates comprised primarily of cobble and gravel with some sand. Available instream cover was considered good. Embeddedness of substrates was not a problem although some siltation from Gilboa Brook (which enters the mainstem river at the upper end of the stream reach sampled) was present along the eastern edge of the stream. Disturbed sediments near the mouth of Gilboa Brook emitted anaerobic/petroleum type odors. Oil sheens were also observed. Banks were fairly well stabilized by vegetation which included viburnum, witch hazel, elderberry, red maple, white oak, and ash, although a few erosional areas were present. Depth ranged between 7.6 to 30 cm in the riffles and up to 0.91 m in the pools. |

Table 2. Summary of habitat evaluation and stream discharge information for biomonitoring stations (MF03A, MF03B, MF04A, MF05) sampled in the Mumford River on 7 and 9 September 1993 as part of the Blackstone River Basin survey.

| STATION | MF03A[R] Mumford River upstream of E. Douglas POTW | MF03B Mumford River downstream of E. Douglas POTW | MF04A[R] Mumford River upstream of Gilboa Brook | MF05 Mumford River downstream of Gilboa Brook |
|---|---|---|---|---|
| HABITAT PARAMETER* | | | | |
| Bottom Substrate | E | E | E | E |
| Available Cover | E | E | G | G |
| Embeddedness | G | G | E | E |
| Velocity/Depth | G | G | G | E |
| Channel Alteration | E | E | E | G |
| Bottom Scouring/Deposition | E | G | G | G |
| Pool/Riffle Run/Bend Ratio | G | G | G | G |
| Bank Stability | E | E | F | G |
| Bank Vegetative Stability | E | E | G | E |
| Streamside Cover | E | E | G | E |
| HABITAT ASSESSMENT-TOTAL SCORE | 115 | 112 | 99 | 111 |
| COMPARABILITY TO REFERENCE SITE | 100% | 97% | 100% | 112% |
| MEAN VELOCITY (fps) | 1.0 | 0.7 | 0.6 | 0.4 |
| DISCHARGE (cfs) | 12.1 | 13.0 | 16.8 | 17.7 |

* Ranked as follows: E=Excellent; G=Good; F=Fair

R Reference Station

Table 3. List of macroinvertebrate taxa collected from four stream sites (MF03A, MF03B, MF04A, MF05) in the Mumford River on 7 and 9 September 1993 as part of the Blackstone River Basin survey.

BLACKSTONE RIVER BASIN--Mumford River Benthos

| TAXON | FFG | TV | MF03A | MF03B | MF04A | MF05 |
|---|---|---|---|---|---|---|
| Naididae | GC | 9 | | 1 | 16 | |
| Tubificidae | GC | 10 | | 11 | | |
| Lumbriculidae | GC | 7 | 13 | 16 | 11 | 21 |
| Erpobdellidae | PR | 8 | | 2 | 1 | 3 |
| Hyalellidae | GC | 8 | | | 2 | |
| Hydracarina | PR | 6 | 1 | | | 2 |
| Baetidae | GC | 4 | 2 | 1 | 9 | 2 |
| Siphloneuridae | GC | 7 | | 1 | | |
| Oligoneuriidae | FC | 4 | 18 | | 2 | 10 |
| Heptageniidae | SC | 4 | 22 | | 18 | 51 |
| Ephemerellidae | GC | 1 | | | 1 | |
| Gomphidae | PR | 5 | | 1 | | |
| Calopterygidae | PR | 5 | | 1 | 1 | |
| Coenagrionidae | PR | 9 | | | 9 | 1 |
| Perlidae | PR | 1 | 3 | | | |
| Corydalidae | PR | 5 | | | | 2 |
| Philopotamidae | FC | 3 | 5 | | | 4 |
| Polycentropodidae | FC | 6 | 1 | | | |
| Hydropsychidae | FC | 4 | 28 | 14 | excluded | excluded |
| Glossosomatidae | SC | 0 | 3 | | | |
| Brachycentridae | FC | 1 | | 2 | | |
| Limnephilidae | SH | 4 | | | | 1 |
| Leptoceridae | PR | 4 | 1 | 2 | 10 | |
| Elmidae | SC | 4 | 1 | | | 1 |
| Tipulidae | SH | 5 | 1 | | | |
| Simuliidae | FC | 6 | 1 | | | |
| Chironomidae | GC | 6 | 2 | 66 | 18 | 3 |
| Empididae | PR | 6 | 1 | | | |
| Planorbidae | SC | 6 | | | | 1 |
| Pisidiidae | FC | 6 | | | | 1 |
| TOTAL | | | 103 | 118 | 97 | 103 |

Table 4. Summary of RBP II data analysis for macroinvertebrate communities sampled at four stream sites (MF03A, MF03B, MF04A, MF05) in the Mumford River on 7 and 9 September 1993 as part of the Blackstone River Basin survey. Seven biological metrics were calculated and scored (in parentheses) for taxa collected at each station. Scores were then totaled and compared to the upstream reference station. The percent comparability to the reference station yields a final impairment score for each study site.

RBP II DATA SUMMARY FOR BLACKSTONE RIVER WATERSHED; DATE: 7-9 September 1993

| STATION # | MF03A* | | MF03B | | MF04A** | | MF05 | |
|---|---|---|---|---|---|---|---|---|
| STREAM | Mumford River | | Mumford River | | Mumford River | | Mumford River | |
| HABITAT SCORE | 115 | | 112 | | 99 | | 111 | |
| TAXA RICHNESS | 16 | (6) | 12 | (3) | 12 | (6) | 14 | (6) |
| BIOTIC INDEX | 4.25 | (6) | 6.19 | (3) | 6.14 | (6) | 4.89 | (6) |
| EPT INDEX | 9 | (6) | 5 | (0) | 5 | (6) | 5 | (6) |
| EPT/CHIRONOMIDAE | 41.50 | (6) | 0.30 | (0) | 2.22 | (6) | 22.67 | (6) |
| RIFFLE COMMUNITY: SCRAPERS/FILTERERS | 0.49 | (6) | 0 | (0) | 9 | (6) | 3.53 | (3) |
| % CONTRIBUTION (DOMINANT FAMILY) | 27% | (6) | 56% | (0) | 19% | (6) | 50% | (3) |
| COMMUNITY SIMILARITY | 100% | (6) | 28% | (0) | 100% | (6) | 39% | (3) |
| TOTAL METRIC SCORE | | 42 | | 6 | | 42 | | 33 |
| % COMPARABILITY TO REFERENCE STATION | | | 14% | | | | 79% | |
| **Biological Condition - Degree Impairment** | **Reference** | | **Severely Impaired** | | **Reference** | | **Non Impaired** | |

* Upstream reference station for MF03B
** Upstream reference station for MF05